POWER PLANT ENGINEERING

Established Over 29 Years

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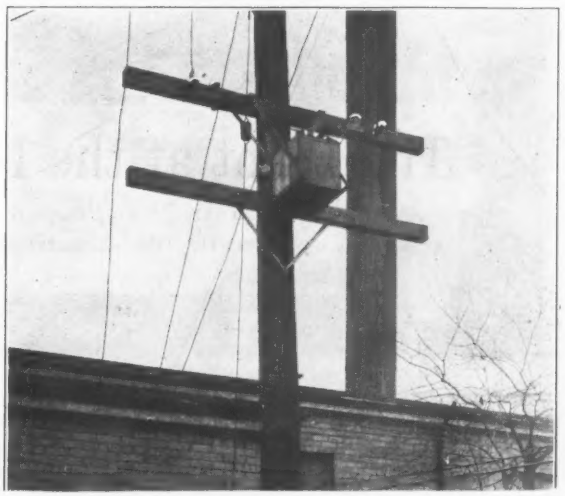
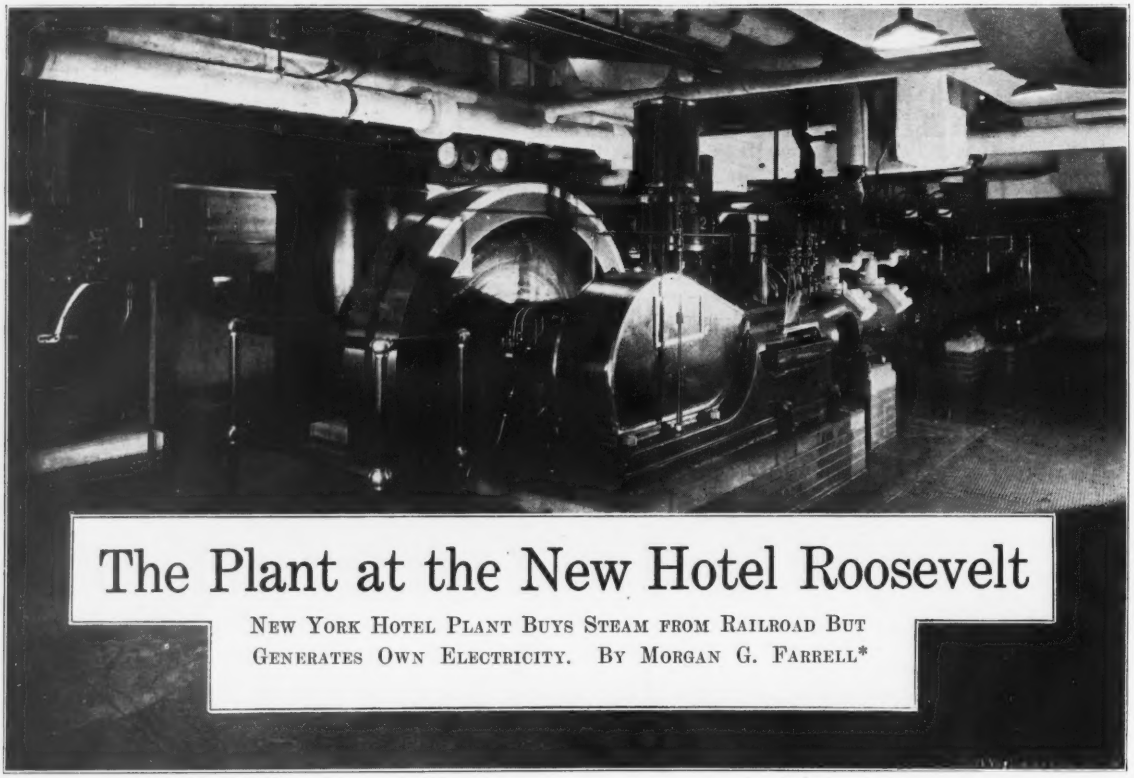


A Storage Tank for Electricity

AS A STORAGE tank for electricity, the box-like affair on the pole in the above photograph doesn't look as if it could hold much. As a matter of fact, it doesn't but that in no way limits its use as a reservoir. Its value lies in its peculiar ability to store a small amount of electricity for an extremely short time—a small fraction of a second. Magnetic fields associated with inductive equipment require energy for their establishment but return this energy to the line every half cycle. This periodic interchange of energy between the inductive apparatus and the generator results in a serious heating loss. It is apparent that if it were possible to store the energy necessary for the production of the magnetic field at a point close to the inductive apparatus during the time interval that it is not needed, this heating loss could be avoided. The way in which the device on the pole does this is described on page 143 of this issue.

IT IS A PECULIAR fact that in the development of mechanical equipment, we usually hit upon the most complicated methods first. Then, gradually as improvements are effected, the device, whatever it may be, becomes simpler and when it is finally perfected we wonder why we didn't think of the simplest method first. In the heating of feed water by extraction steam, for instance, the first arrangements made use of multiple heaters and pumps. Now that extraction heating has been used for some time we suddenly discover the much simpler arrangement described on page 132.



The Plant at the New Hotel Roosevelt

NEW YORK HOTEL PLANT BUYS STEAM FROM RAILROAD BUT GENERATES OWN ELECTRICITY. BY MORGAN G. FARRELL*

WITH THE COMPLETION of the new Hotel Roosevelt there has recently been inaugurated a new departure in the economics of power plant operation for large buildings. The problem was to determine whether to buy steam and current or to generate one or both. The solution is ingenious.

The Roosevelt is the latest of the great hotels. It occupies a block about 200 by 230 ft. at Madison Ave. and Forty-Fifth St. It is 20 stories high and contains 1000 guest-rooms. The site is in that restricted area known as the Grand Central zone located north of the New York Central Railroad depot. Roughly, this zone is about 1000 ft. wide by 2500 ft. long and includes land purchased by the New York Central Lines for subterranean car yards.

When the land was acquired all existing buildings were demolished and the immense excavation for two layers of tracks was completed. An all-steel structure was erected in the excavation to carry the upper and lower track levels and the streets as well. Between streets the steel columns were designed to support future 20-story buildings to be erected over the tracks. All new buildings were to conform to the architectural scheme worked out for the entire zone.

Naturally this left many of the buildings without basements. The railroad therefore arranged to supply them with steam and electric current from its central power station in the district.

The Roosevelt, however, is located partly over the tracks and partly on terra firma—about half over each. This made basements possible, though the area of each level is limited to half the plot area and the number of levels (three) is equally limited by the solid rock excavation necessary to accommodate them.

*Vice President, Frank Hill Smith, Inc.

Thus the first phase of the problem presents itself. The owners said to their engineers: "We can use all the basement room we can get. There won't be half the space we need below ground in any case; so if you can leave out the power-plant without adding to our running expenses, do so."

The conclusion reached by them may be summed up about like this: "It will cost as much to generate steam as to purchase it from the railroad. If steam is bought, basement space for boiler-rooms, coal storage, pumps and auxiliaries will be released for other use. Besides the dirt, heat and the handling of fuel and waste will be eliminated; therefore steam will be bought.

Since the railroad supplies only live steam at 125 lb. pressure and since there is ample use for exhaust steam to supply the radiators half the year, and to heat the vast amount of water consumed all the time, it was found to be cheaper to install steam-driven generators than to buy all-electric power. Arrangements were made, however, so that the load can be thrown wholly or partly on the house busses or the railroad's busses, according to the operating plan described farther on.

STEAM AND POWER DEMAND

Before indicating the novel points in plant and operation, it will be well to outline briefly the internal economy of the hotel and the numerous departments requiring power, steam and water.

Elevators, blowers and exhausters for the ventilating system, and the auxiliaries in the engine-room, are the largest consumers of electric power. Next come the laundry and kitchen equipment and the repair shops. The lighting load is, of course, highly variable. Power is supplied at 220 v. It is direct current exclusively, being governed by the New York Central supply which is direct

current. The lighting system is the usual three-wire distribution at 110 v.

Some notion of the power requirements of a large hotel may be suggested by the number of motors employed throughout the building for all purposes. There are 156 in all with a total connected load of 1300 hp. The ventilation system alone requires 24 motors of 200 hp. total.

Live steam is required principally for the main engines, the steam-driven ammonia compressors and some auxiliaries; for the laundry and the kitchens. Exhaust steam is used for heating the building, for the hot-blast coils, the Turkish bath and above all for heating the enormous amount of hot-water used in laundry, kitchens and all the lavatory and bath-rooms throughout the hotel. The average daily consumption of live steam during October 1924 was 900,000 lb.

The hot-water consumption is on a corresponding scale. It averaged 300,000 gal. a day during the same month. One can imagine the demand for hot water between five and six in the evening with the greater part of a thousand room-taps running, the Turkish bath, kitchens, laundry, barber-shop and all the rest in full swing. In fact peak-loads are characteristic of hotel power plants. They coincide with meal-hours, small in the morning, larger at noon and a maximum from 5 p. m. on until 8, then gradually diminishing to midnight.

There is a multitude of auxiliary mechanical systems requiring equipment in the power plant; such as: a 30-station pneumatic tube system, the vacuum cleaner piping, the ice-making and drinking-water cooling plant, sewage ejectors for the lower levels, call, alarm and telephone systems, vacuum returns, drip and oil piping and so on.

The Power Plant

The main engine-room is on the third and last level below the street. The plan shows its layout. Steam at 125 lb. pressure from the New York Central power house, enters at the rear (the top of the plan) and passes through duplicate steam-flow meters to the engine room header. Thence it is distributed to the power refrigeration and compressor units.

The 220 v. d. c. electric lines enter at the same side and are metered in the little room at the upper left. Thence the feeders pass to the railroad or "outside" set of bus-bars in the room back of the switchboard.

There are three main power units, all of the same size and make. Each is a simple, non-condensing Skinner Unaflow engine direct connected to a 300-kw. General Electric, 220-110 v. d. c. generator. The generator leads pass to the "house" set of busses back of the switchboard.

Adjoining them on the plan are two 40-T. and one 20-T. De La Vergne ammonia compressors direct connected to Ames non-condensing engines. These, with the ammonia receiver and three brine pumps, are in the main engine room; the rest of the refrigerating apparatus is on the floor above.

Two single-stage, steam driven air compressors furnish compressed air for discharging the sewage ejectors shown in the upper left-hand section of the plan. Two other small compressors deliver air for the pneumatic tube system at a very low pressure: 1 lb. or slightly over. All the compressors are automatically controlled. The first two are

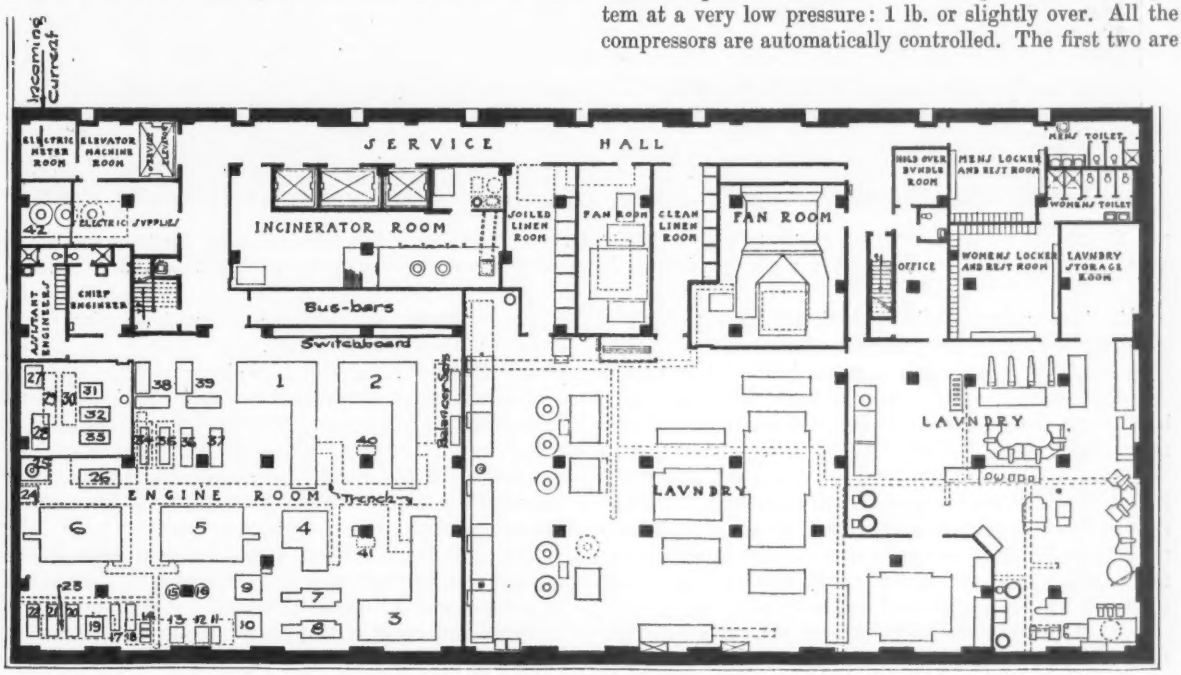


FIG. 1. THIRD BASEMENT PLAN OF HOTEL ROOSEVELT SHOWING LOCATION OF LOWER ENGINE ROOM

1, 2, 3 Engine Generators
4 20 T. Ice Machine
5, 6 40 T. Ice Machines
7, 8 Air Compressors
9, 10 Pneum. Tube Compressors
11 Lubric. Oil Tank
12, 13 Lubric. Oil Filters
14 Lubric. Oil Pumps
15, 16 Receivers for 7 and 8
17, 18 Ice Water Makeup Pumps
19 Do. Circul. Pump
20, 21, 22 Brine Pumps
23 Ice Water Tank
24, 25 Oil Return Tanks
26 Oil Extractor
27, 28 Return Tanks
29, 30 Preheaters
31, 32, 33 Sump Pumps
34, 35 H.W. Heaters and Tanks
36, 37 H.W. Pumps
38, 39 Radiation System Receiver and Pump
40, 41 Lubric. Oil Tanks
42 Sewage Ejectors
43 Ice Tank
44 Blower
45, 46 Vac. Cleaners
47, 48 House H.W. Heaters
49, 50 C. W. Meters.
51, 60 Water Filters
52 Suction Tank House
53 Suction Tank Fire
54 Fire-Pump

steam-driven, the others, motor-driven. No steam condensing equipment is provided.

Smaller equipment in the same room is best described in terms of the system served:

(a) Two motor driven wet-vacuum pumps with receivers which discharge the condensate from the house-heating system into two preheaters. All incoming water from city mains flows through these preheaters. Their purpose is to extract the residual heat from the returns as they pass through them on the way to the sewer.

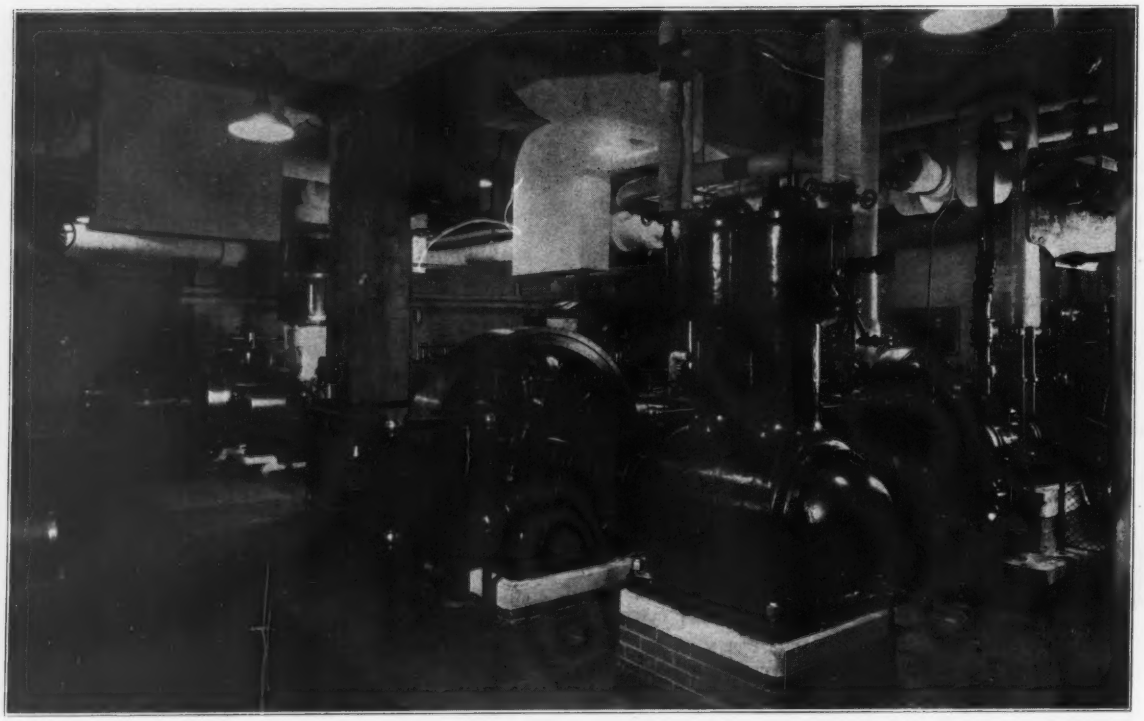


FIG. 2. TWENTY TON ICE MACHINE IN FOREGROUND. BEHIND TO THE RIGHT ARE THE AIR COMPRESSORS. GENERATOR NO. 3 AT THE LEFT. NOTE THE LUBRICATING OIL TANK AT THE TOP OF COLUMN TO THE LEFT OF ICE MACHINE.

(b) Two return tanks and three sump pumps for emptying them into the preheaters. They take care of all high and low-pressure condensation. While all returns go into the sewer, they give up practically all their surplus heat to the incoming water whose temperature is thereby raised about seven degrees.

(c) Two heaters, two 1000-gal. hot-water tanks with two 300-gal. house pumps direct connected to 40-hp. motors take the water as it comes from the preheaters, raise it to 130 deg. and send it on to the hot-water distributing tanks in the upper part of the building. There are similar tanks and pumps for the laundry and kitchen.

(d) Two circulating pumps, and a cooling tank connected with the refrigerating system, for the drinking water supply in all the hotel rooms and corridors.

(e) The oiling system includes the oil-extractor, oil return tanks, filters, and a set of three pumps. One pump delivers filtered oil to an elevated cylinder oil tank and the other to a similar lubricating-oil tank.

(f) Two balancer sets for the lighting system.

The switchboard is of interest in that it is fitted with two sets of busses of like capacity all placed in a large room back of the board. There are 14 panels each controlled by two sets of circuit-breakers linked together to give a double-throw effect. The panel division is important, for each large department of the hotel is charged with the power and light current it consumes. The panel circuits are divided as follows:

Panel 1: Meters, lighting balancer sets,
Panels 2, 3 and 4. Generators,
Panel 5: Main power and light meters,
Panel 6: Power for ventilation fans,
Panel 7: Power for ventilation fans and refrigeration system motors,
Panel 8: Power for kitchen and laundry equipment,
Panel 9: Power for elevators,
Panels 10 to 14: Lighting circuits.

On each generator panel is mounted a field temperature limit alarm and indicator. The fixed limit indicators are set at 30 and 75 deg. When the temperature indicator reaches either limit the alarm sounds and the operator transfers the load to another generator or to the "outside" bus-bars.

The gage-board bears five instantaneous gages indicating the heating steam pressure (kept at 5 lb.), the heating return pressure or vacuum, the heat regulation pressure, the pneumatic tube system pressure (about 1 lb.) and the ejector air pressure (about 50 lb.). It also carries the following recording gages. Live steam pressure (125 lb.), laundry steam pressure (80 lb.), kitchen steam pressure (30 lb.), kitchen hot-water temperature (150 deg.), laundry hot-water temperature (150 deg.) and two house hot-water tank temperatures (130 deg.).

Live-steam pressure is brought down to laundry and kitchen requirements by regulation reducing-valves.

The engine-room on the upper or second level contains:

(a) The brine tank with a traveling electric crane for lifting out the ice molds.

(b) A set of six water filters,
(c) A low temperature cooler for freezing ice cream,
(d) Two vacuum cleaner units,
(e) Two suction tanks, one for house cold-water and one for fire use, and
(f) The electrically-driven fire pump.

On this floor are the several refrigerator and ice rooms, ice cutting, ice-cream room, etc., as well as the steam-meter room.

The Use of Steam and Hot-Water

High pressure steam is used by the laundry for the cylinders of the large ironing machines for sheets and tablecloths, and of smaller machines for napkins, pillow-slips, towels and the like. Also for raising the temperature of the hot-water in the washing-machines. The laundry has a capacity of 100,000 assorted pieces, daily.

There is one main kitchen on the first floor between the main dining rooms. Here food is prepared for all the other rooms. In addition there is a pantry to serve the restaurant on the ground floor, another for the help's cafeteria in the first basement, a third for the banquet hall and private dining rooms on the mezzanine and a fourth for the officers and private dining rooms on the second floor. The kitchens and all the pantries are generously equipped with steam tables to keep food at the proper temperature. They are supplied with high pressure steam reduced to 30 lb.

The hot-room and steam-room of the Turkish bath are supplied with exhaust steam, but there is an auxiliary high-pressure line with branches fitted with reducing valves which can be used in emergencies to supply these and all other coils, heaters and radiators normally supplied with exhaust steam.

As already indicated, there are four hot-water heaters with exhaust steam feed, four storage tanks and four pumps. Two of each supply the Turkish bath and all the lavatories and bath-rooms throughout the building; one is reserved for the laundry and one for the kitchen and pantries.

When exhaust steam is used for heating, the problem always present is: what to do with the surplus during the milder half of the year. In factories it is usually wasted. In a hotel the demand for exhaust steam for hot-water heating, steam-coils in the kitchens, laundry service and similar uses is so large a percentage of the total amount of available exhaust that there is comparatively little waste during the summer months.

Total heating surface of all the radiators in the Roosevelt is about 20,000 sq. ft. The total amount of steam required by it is about one-fourth the aggregate exhaust of the engines, ice-machines and auxiliaries, provided that all radiators and coils are open, an exceptional condition.

During the day not more than half the radiators are in use. Room attendants are instructed to turn them off, when the guests are out. When they return in the late afternoons and turn on the steam again, the early darkness has caused the lighting load to be thrown on the generators, thus increasing the weight of the exhaust steam supply. The full lighting load is some 300 kw., the average about half that amount. This additional load provides more than enough steam for the radiators. The surplus is required for the evening hot-water demand. Thus the balance between exhaust steam supply and demand is equalized automatically and naturally, so that there is comparatively little loss.

The cost-accounting system of a hotel like the Roosevelt, operated as one of a chain and hence subject to rigid comparison, must be as thorough as that of a large factory. It is divided into productive, indirectly productive and non-productive departments exactly like a manufacturing establishment.

Directly productive departments, for example, would include: Kitchen, roof-garden, four dining rooms, ball, banquet and private dining-rooms, chambers, stores and concessions and the laundry, valet, Turkish bath, barber shops, beauty-parlors, etc.

Indirectly productive departments are the power plant and all its subdivisions, storage rooms, helps quarters, executive offices, front office, baggage department, general service departments and repair-shops.

Non-productive departments are the public-rooms such as the lobbies, lounges, palm-room, library and the rest.

Classification depends upon whether the departments bring in revenue directly, contribute to revenue production or are wholly without revenue.

Whatever its classification, each department is charged with a space-rental, light, heat, steam, water and power. Of these the space rental is fixed; so is the heat charge, which is based upon heating surface.

Light, steam, water and power are metered in large sub-divisions. For instance, there are six steam-flow meters apart from the general meters of the N. Y. Central Railroad. These six meters measure the supply of:

(a) Live steam to the engine-generator sets,
(b) Live steam to the refrigerating system,
(c) Live steam to the steam-driven auxiliaries,
(d) Live steam to the kitchen,
(e) Live steam to the laundry,
(f) Exhaust steam to the hot-water heating system.

Electric power is metered by six divisions:

(a) Ventilating blowers and exhausters,
(b) Circulating pumps,
(c) Refrigeration system auxiliaries,
(d) Kitchen machinery,
(e) Laundry machinery,
(f) Elevators.

Lighting current and water measurements are more finely subdivided. There are some 24 main lighting circuits, but they are not metered separately.

Two sources of electrical energy, the house power plant and the railroad feeders, are ingeniously utilized. The price per kilowatt hour of the outside power is somewhat higher than a corresponding public service a. c. supply would be. It is also higher than the cost of making house power. Consequently it is advantageous to run on the generators as long as they are operating at an economical load. As their size is sufficient so that the three of them can carry the whole electrical load of the hotel, it is only economical to operate all three at peak periods. As soon as the load falls off, one of the engines is shut down and the load transferred to the other two. If it is too much for them the surplus is relieved by throwing it on the railroad supply through one or more of the double throw branch circuit-breakers. As the load diminishes further the auxiliary supply is cut off again.

Outside supply feeders, breakers, and busses are also of sufficient capacity to carry the full load, so that it is a 100 per cent breakdown service.

The third advantage of the outside service is that it can carry an over-load beyond the combined capacity of

the generators, if the addition of equipment should ever cause the full load to exceed that capacity.

Transfer of load to and from the outside busses does not complicate the distribution of power charge since the total of all branch meters will equal the sum of the outside meter reading plus the main house meter reading. When the outside power bill is received it is added to the house power cost and the sum is distributed pro rata among the branch circuits.

All the charges for power, water, etc., are thus billed directly to the hotel departments whether they are productive, non-productive or indirectly productive. It is the cost accountant's duty to re-distribute the general overhead among the productive departments so that it shall be applied to the cost of food, service, rental, etc.

FIG. 3. ONE OF THE UNAFLOW ENGINE GENERATING UNITS, SHOWING SWITCHBOARD IN BACKGROUND

Power Plant Personnel and Shops

S. Barnaby, Chief Engineer of the Roosevelt, is executive-in-charge, not only of the power plant, but of all repair shops, mechanics and trades. He is responsible for all repairs, alterations and renewals throughout the building, for the purchase (through the general purchasing agent), of supplies and materials mechanical and structural, for their storage and expenditure.

The shops include a fully equipped machine shop on the second basement level with a complement of lathes, drill-presses, millers, shapers, etc., capable of repairing any but the largest parts. There is an electrical repair shop and a pipe-shop near the engine room. The garbage and waste incinerator come under the same direction. In passing it may be noted that the incinerator is purely a destructor. It is coal-fired and no attempt is made to recover any of the waste heat. The garbage is sorted on the floor above and fed into hoppers discharging into the incinerator. Recent tests have shown that garbage consumers on a small scale are poorly adapted to the by-production of hot water or steam. It takes about all the heat of the fuel to dry and burn the garbage and the fuel value of the latter is negligible.

On account of the limited basement space, the remaining shops are in the pent-house on the roof of the hotel. Here are located a well-equipped carpenter shop for both bench and machine work, the locksmith's shop, the upholstery shop, a paint-shop with paint and oil closet and a drying room equipped with forced ventilation as well as a printing shop for turning out the daily menus, notices and all but bulk printing.

While these shops are efficient in themselves, their location on the roof is open to criticism. They are too far from the central control in the power department, as well as from the sections of the building in which their services are most likely to be required; that is, the lower floors. Moreover all material received at street level must be transferred to them by elevator and brought back again to the point of use; however, the exigencies of more important departments demand that basement space be assigned to them and to their auxiliaries so that there is no other apparent location for these shops.

Here is the organization diagram of the Chief Engineer's force:

Chief Engineer

Three Clerks

First Ass't Eng'r	Chief Electrician	Foreman Painter
Four Watch Eng'rs	Fourteen Elec'ns and Helpers	Five Painters
One Machinist	Two Elevator Engineers	
Two Locksmiths		Foreman Carpenter
Four Oilers		Eight Carpenters and Helpers
Eight Handy and Relief Men		
Two Thermo Eng'rs		
One Steam Fitter		
One Plumber		
Three Ice Men		
Three Incinerator Men.		

In all, 66 men; the size of this force gives an idea of the extent of the mechanical requirements of a large hotel. It would be a large repair shop which numbered as many mechanics, yet this is but a skeleton force. These men are employed constantly during working hours, either for fixed duties or current repairs. In emergencies or extraordinary repairs their numbers are considerably augmented by temporary additions. If the work to be done is extensive, it is usually awarded to contractors, as it would be obviously uneconomical to employ plasterers, tile-setters and so on for casual jobs in those trades.

General Comment

While it may appear at first impression that a hotel is a highly specialized organization and that the power conditions in this particular hotel are even more highly specialized, the working out of the problem is full of suggestions to operators of other commercial and industrial power plants.

First in order is the provision of an electrical "breakdown" service of adequate capacity. The foregoing has shown that the term "breakdown" is a misnomer. It suggests the improbable contingency that one or all of the main generating units will be completely out of commission for a protracted period. If it were only of use in a breakdown, outside power service would be costly insurance. Plants run for years without interruption, and one shut-down for a few hours costs less in lost production than the aggregate stand-by charges of the public service company for that period of years.

The more logical conclusion is that the public supply is an elastic auxiliary which should be used when it is cheaper, even for short periods, than house or plant power would be. It is common to see an entire factory power plant in operation to supply a few departments during slack periods, often lasting weeks and months, at a cost far in excess of that of purchased power making all allowances for stand-by and maximum demand clauses in the contract. If an intelligent tabulation of comparative power costs is made it will not be difficult to determine when to shut down private plant and transfer to the public supply.

Another important suggestion of the Roosevelt plan of operation of special interest to manufacturers is the simple and direct charge of steam, power and water to the several departments. The usual argument against a proper metering system is: "What is the use of spending a lot of money on meters to tell us how much to charge against a department? It all goes into the cost of the finished goods anyway. Why won't an approximation serve all practical purposes?"

The answer is: "Why have a cost-system at all if it is as simple as all that? Why not take the over-all cost of labor, material and overhead, add the profit and call the result the selling price?"

The only trouble with that method is that the selling price is too high to get the orders in a competitive market and the only way to get that price down is to reduce the production cost. The only way to do that is to know the exact amount of every element entering into the cost at *each* step of the process. So only can leaks be located and stopped.

Still another suggestion is the segregation of all physical plant under the control of the chief engineer. In most plants the superintendent whose chief job is to get out production is charged with the additional duties of plant maintenance and power production. These two functions subordinate to the superintendent, just as any other foreman would be. In large corporations he is called the works engineer. He is in charge of the power generation and distribution, the repair and upkeep, of all mechanical equipment, pipe-lines, yards, rolling-stock and buildings. It is safe to say that if he is competent, he can save his salary many times over by minimizing shut-downs and call for the undivided attention of an experienced man repairs, saving material and supplies and salvaging for service many items usually sent to the scrap-heap by an over-worked superintendent.

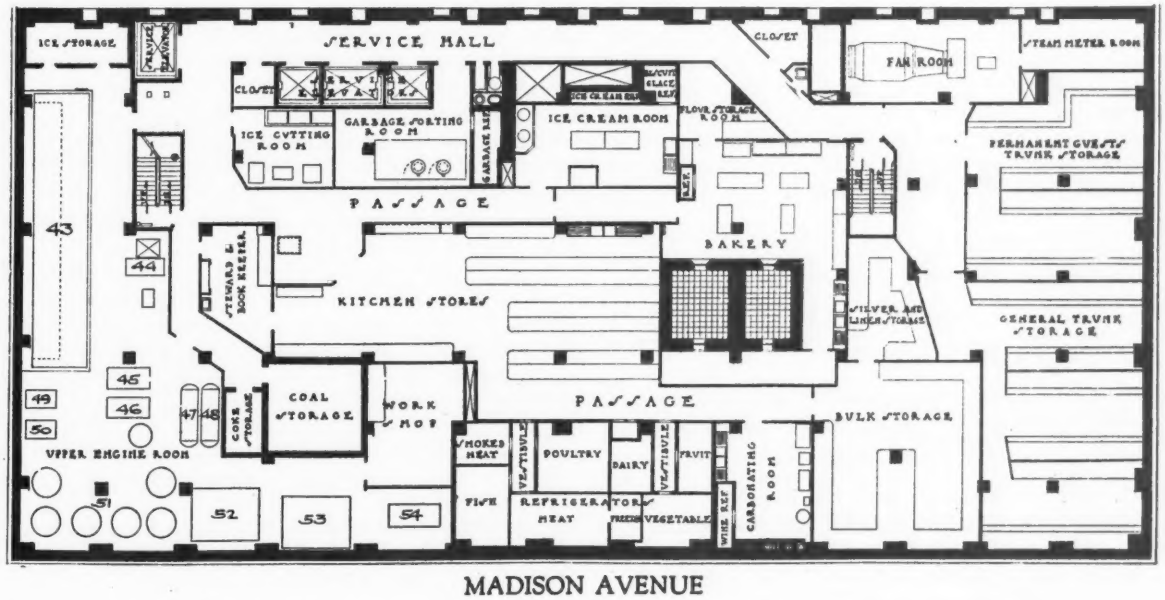


FIG. 4. THE SECOND BASEMENT SHOWING UPPER ENGINE ROOM IN LOWER LEFT HAND CORNER

Smoke Prevention

RENEWED activities by civic authorities and organizations in the campaign to eliminate the smoke nuisance are reported as following a study of the problem of smoke abatement made by the Bureau of Mines. This campaign was suspended during the World War, when most of the smoke ordinances throughout the country were held in abeyance so that industries could operate unrestrictedly during the time when maximum production was necessary. With the return to normal conditions many cities have shown a determination to take up this matter seriously and to work out a solution. Some 50 or 60 cities in the country already have smoke ordinances.

In domestic furnaces, it should be possible to reduce smoke from 50 to 75 per cent without spending any money for additional equipment or without any change except in methods of handling the fuel. At industrial plants, smoke prevention is merely a matter of management, engineering judgment, and designing skill. Any locomotive properly equipped with standardized smoke-abatement devices can be made to do its required work without making dense smoke. All metallurgical operations can be conducted smokelessly with powdered coal, coke, fuel oil, or producer gas.

Installation of Steam Turbines

Usefulness and Life of a Unit Will Be Prolonged by Proper Installation.

By J. Y. Dahlstrand*

WHEN TURBINES OR turbine units are installed in old buildings particular care should be taken, wherever possible, that they be installed in places as free as possible from dirt and dust. The illumination at all times of the day should be good in order that parts may be readily inspected and kept clean. All parts, which require periodic inspection, such as oiling systems and strainers, should be so located that they can be readily taken apart for inspection. Wherever possible, it is advisable to provide an over-head crane and where this is not possible, over-head beams are advisable to which hoists can be attached for lifting the covers and rotors.

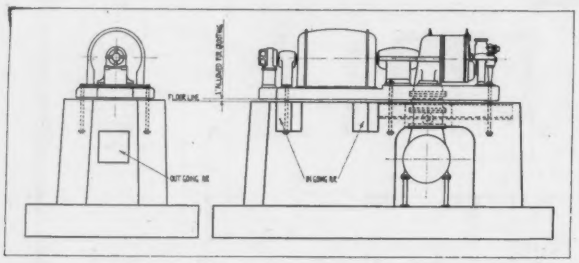


FIG. 1. SPACE SHOULD BE LEFT FOR GROUTING BETWEEN THE FRAME OR BED PLATE AND THE FOUNDATION

In general, sufficient attention is not paid to such points as cleanliness around turbine units; especially in such cases where they are installed in old plants. Such precautions, however, will generally pay dividends in that a clean unit will nearly always receive much better care and consequently will last longer than one which is covered with dirt, dust and oil. American power plant owners can well pattern in this respect after European practice where power plants are clean and where considerable expense is gone to to "dress up" the stations.

The purpose of the foundation is first to provide a proper footing upon which to set the turbine unit. A second purpose is to maintain proper alinement between the two or three members of the unit. This latter point is not generally well understood, as it is often thought that this is the purpose of the bedplate. As a matter of fact, even a heavy bedplate can be sprung out of shape and cannot be depended upon to hold the unit in line. The alinement, therefore, is made correct when the unit is on the foundation and the bedplate securely grouted to it.

One common type of foundation is the concrete foundation, which may have steel beam reinforcements. In some cases, however, structural steel foundations are put under turbine units resting upon concrete slabs. The foundation plate should generally be put down so that it rests on firm sub-soil and in that case need not be more than about one and one-half times the area of the bedplate, depending somewhat, of course, upon the weight of the unit. Foundations should never be tied solidly to walls or buildings. They should extend up independent from the walls and each other if there is more than one unit.

Reinforced concrete foundations are probably to be preferred on account of the greater mass of material with resulting greater rigidity and less aptitude for vibrations. The concrete foundation is much to be preferred with geared units on account of the above-mentioned fact, since such units always produce a certain amount of noise, which, in a steel foundation, is liable to be intensified through harmonic vibration. Wherever possible, it is advisable to fill the bedplate completely with cement which deadens the sound and gives a particularly rigid alinement.

Foundation bolts may or may not be used as may seem advisable. In many cases, where the bedplate is completely filled with concrete, or where the concrete is run to the top of the bedplate completely surrounding it, foundation bolts are not necessary. With smaller units, foundation bolts are practically always used.

When a concrete foundation is built as a mass and rests on soil or rock, foundation bolts should be accurately located in their proper position and surrounded by a pipe about three times as large as the diameter of the bolt in which the bolt can be moved around to conform to the necessity of properly locating the unit.

In many cases, the foundation bolts are cast in concrete and in other cases holes are drilled in the concrete and bolts set in afterwards. If a steel rod, which is clean and free from scale, is embedded in concrete to a depth 40 times its diameter and cement poured around it and allowed to set, the rod is so firmly held that its full strength is developed before the rod will slip.

If a baseplate is used, it should be set on steel wedges or shims and bolted down by means of foundation bolts. Before grouting, the alinement must be kept in check and readjusted, if necessary, with the machine placed in a level position. The bedplate should then be grouted in and wherever possible, the bedplate should be filled up with cement. The steel wedges and shims may be removed after the concrete has hardened. The grouting is generally made of sand and cement mixed in a proportion of three to one. It should be mixed wet and poured as a liquid so that it will flow to all parts of the bedplate. If the concrete and bedplate are in a hot room, the new grouting should be kept wet to prevent surface shrinkage.

In cases where exhaust pipes have to be put through concrete foundations, care should be taken that there is ample clearance for removal of bolts in flanges. Steam foundations and exhaust pipes should never be grouted solidly into foundations. In case of alternating current generator units, the air ducts for the incoming and outgoing air are generally cast in the foundation. Manufacturers will furnish an air duct plan, which shows an arrangement to furnish ample capacity of air and still maintain proper strength in the foundation under the generator end of the unit.

Method of Alinement of Shafts

After the turbine unit has been placed upon its foundation, grouted and bolted down, a recheck of alinement is generally made. The best method for checking and alinement is as follows: Shafts connected with couplings may, in general, suffer from two kinds of misalinement. They may be out of line sideways, in other words, the ends of their axis may not meet or they may be non-parallel. It is always possible to check the alinement of two shafts

*M. E. Standard Turbine Corp.

from the two coupling halves even though these coupling halves may be imperfectly machined so as not to have their faces perpendicular to the axis nor their outside diameter concentric with the shaft. While, in the majority of cases, couplings are machined so as to be fairly accurate, the method described below disregards the accuracy of the coupling. In all cases, it should be stated, however, in order that there may be no mis-understanding that unless the couplings are fairly accurately machined the fact that the shafts are in line does not necessarily mean smooth operation. There are two requirements to be fulfilled in order that two coupled shafts are to be in line:

The first one is that the distance (A) between the coupling halves, Fig. 2, is the same whether this point is up or down, or on the right or left-hand side when the two shafts are turned together when measuring this dimension.

If a pin type coupling is used, a convenient way of doing this is to insert a loose pin through both halves of the coupling and leave this in while turning and measuring. While taking the measurements, the two shafts should be pushed as far apart as their respective thrust bearings will permit, after determining that the thrust collars on the shaft run true and perpendicular to the axis of these respective shafts.

In the second place, it is necessary that the dimension (B) at the point (1), as indicated in the figure mentioned, should be the same, no matter whether this point is up on the right-hand side or down on the left-hand side. It is important to remember that when taking this measurement, both the shafts are also to be rotated together. In case these dimensions are not the same, then they will have to be made the same in order to satisfy a correct alinement.

Modern turbine units are generally designed so as to have ample support on the base plate and through it on the foundation. Feet and pedestals are made of more ample proportions, the manufacturers having begun to realize that a turbine unit transmits a large amount of power for its size and needs rigidity and stability. Thus, if the alinement is correctly made in the first place, the pedestals having been doweled securely to the base plate, the base plate being supported on an ample foundation, there is no reason why a misalinement should ever occur. With the old types of machines with light bearing cases and small turbine feet, which invite misalinement, due to pipe strains and like, it was considered necessary to check alinement at periodic intervals to be sure that nothing had happened to it.

Turbines Must Be Relieved of Piping Strains

Steam piping to the turbine should be so arranged as to impose a minimum amount of strain on the casing. It is not possible to relieve the turbine of all pipe strain and modern turbines are arranged so as to suit themselves to practical conditions in this respect.

Turbines ought always to be so constructed that the top half may be removed without breaking steam lines. Strainers and valves ought also to be removable without breaking steam pipe lines. The steam pipes to the individual units should generally be brought down from a header and each individual pipe should have a large bend upward before going down to the turbine unit. The steam header should be well drained to traps and each individual steam line should be furnished with a steam strainer close to the turbine throttle. In case the steam is not superheated, it is advisable to furnish a steam separator, also a drain connected from this separator to the traps. The throttle valve should be installed below the separator. A combination trip and throttle valve is to be preferred in that it saves space and provides an additional safety feature in connection with the machine. These trip and throttle valves can be mechanically operated, this being a more secure arrangement than steam or oil operated valves, which are dependent upon the assured flow of the media in question and are also subject to leaks.

Best Location for Pump Governors

With pump units it is often desired to install a pump governor ahead of the regular turbine steam chest. This governor would be placed between the throttle valve and

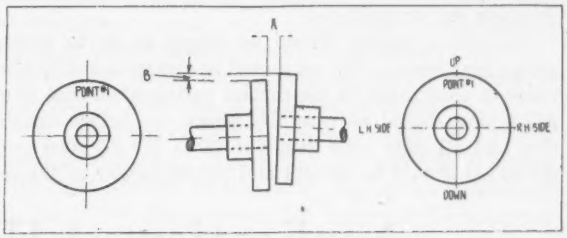


FIG. 2. METHOD OF CHECKING UP TWO SHAFTS WHICH ARE OUT OF ALINEMENT

the steam chest. The function of such a pump governor is generally to maintain constant discharge and suction pressure and there are many especial designs of these governors for various purposes.

With mixed pressure turbines the low pressure steam line is generally equipped with a flow valve, which is arranged to maintain ahead of itself a constant pressure which is slightly above atmosphere. This prevents a vacuum being maintained in the low pressure lines at such times as the load is light. Low pressure turbines are often arranged with no trip valves ahead of a low pressure governor valve, the units depending upon a vacuum breaker to protect the turbine and the driven machine in case of overspeeding. This procedure must, however, be considered unsafe and trip valves should always be provided on these machines.

Low pressure and mixed pressure turbines taking low pressure steam from the exhaust of other steam apparatus should have installed ahead of the throttle an oil separator; generally, a receiver is also advisable to smooth out the flow and pressure. Low pressure steam lines to the turbine should always be provided with expansion joints where necessary since they are generally large in dimension and for that reason might be inflexible. In the exhaust from the turbine, there should always be provided an expansion joint unless the exhaust pipe is small in size and flexible in itself. If the expansion joint is of considerable size, then it may be necessary to stay it in order not to impose too great an unbalanced pressure upon the turbine casing.

If the direction of the forces due to this pressure are radially from the turbine shaft, there is generally no danger of trouble. But if the exhaust pipe is carried up or down a considerable distance and then an elbow put in after which an expansion joint is added, then a considerable moment is set up which tends to tip the turbine over, breaking the feet and the bolts of one side or the other.

XUM

Whether the turbine operates condensing or non-condensing, it is generally advisable to install a gate valve in the exhaust line, which may be shut in case of repairs to the turbine or to the condenser. For condensing turbines, an atmospheric free exhaust valve should be provided between the turbine and the gate valve. It should be set at a pre-determined maximum pressure. There should be no other valves in this free exhaust line and the valve itself should be sealed with water to prevent air leakage through it.

In many cases a so-called back outlet gate valve furnished with such an atmospheric opening is used to advantage where space is an important item. A vacuum breaker is always to be recommended on condensing units, this breaker either to be put on the condenser or the turbine and wherever possible connected to the emergency trip governor on the machine.

All steam piping should be lagged so as to prevent undue heat losses. Piping should be run so as not to allow water to accumulate in the turbine casing when shut down. All piping should be carefully blown out before installation and all pipe scale removed in as far as practicable. All joints should be smooth and perpendicular to the center line of the pipe; flanged pipe being used wherever possible. Thick pipe gaskets should always be avoided as they have a tendency to blow out. Pipe should never be sprung into line and strains should be avoided as much as possible.

Drains should be provided from the turbine casing to a trap and wherever possible, the condenser should be placed below the turbine so that the water will drain direct to the condenser and be removed with the condensate. Where this is not possible, a vacuum trap should be installed below the turbine to drain the exhaust chamber. Similar drains should also be provided from separator, throttle valve and steam header. Drains to traps are generally provided where carbon packing glands or labyrinth glands are used on turbines which are operated condensing. All drains should be of ample proportion so as to assure there being no excessive pressure in them which will prevent them from proper functioning.

In case of units with oil circulating system, water will have to be piped to the cooler or to water-cooled bearings as the case may be and discharge lines put in from these points. For water packed turbine glands, similar water connections will have to be made.

Application of High Pressure Steam[1]

WITHIN A PERIOD OF TEN YEARS BOILER PRESSURES HAVE BEEN INCREASED FROM ABOUT 300 LB. TO 1200 LB. BY B. N. BROIDO*

DEVELOPMENT OF THE steam engine has been mainly a constant struggle to increase the working pressure. Successful experimental tests have been reported from England with a Benson boiler operating above the critical pressure, i.e., 3200 lb. per sq. in. Soon we shall have in this country two or more plants with units operating at 1200 lb. We know of a number of plants under construction, or in project, where the designers originally considered high pressures of 600 lb. and above, but after careful study and consideration of stage feed water heating and stage steam superheating, have decided upon 375 to 400 lb. at 700 deg., due to the present limited knowledge and uncertainty as to all factors involved.

It is well known from the laws of thermo-dynamics that the thermal efficiency of a heat engine depends chiefly upon the temperature range; that in accordance with the Carnot cycle the temperature at which heat is supplied and withdrawn should be as widely separated as possible. In accordance with the Carnot cycle, the maximum efficiency is obtained when all the heat is absorbed at the highest temperature and all the heat to be rejected is discharged at the lowest temperature. If this could be realized in the steam engine, or if all the heat were transferred to the steam at 750 deg. F. or 750 deg. plus 460 deg. equals 1210 deg. F. abs. and all heat were rejected at 80 deg. F. or 80 plus 450 equals 540 deg. F. abs. the Carnot cycle would be realized and the efficiency of the engine would be $\frac{1210 - 540}{1210} = 0.553$ or more than one-half of the heat would be transferred into mechanical energy.

Rejection of all heat at the lower temperature can be nearly approximated as the temperature of the condenser remains the same while the steam is condensing. It is, however, impossible to cause the steam to absorb all heat at the higher temperature. In the boiler, the water is first heated to the steam temperature and heat is absorbed at a gradually increasing temperature; if the steam is superheated, the process of superheating also takes place at rising temperatures. Only the latent heat or the heat of the evaporation is absorbed at a constant temperature corresponding to the prevailing pressure. This heat is a larger part of the total heat transferred from the coal to the steam. It is, therefore, evident that the higher the pressure, the higher is the temperature at which the bulk of the heat is absorbed by the steam, the nearer we approach the ideal condition of the Carnot cycle and the higher is the thermal efficiency of the process.

It is evident that the economy of every existing steam plant may be considerably increased by using an additional steam turbine, or an additional cylinder for a reciprocating engine working at high pressure, the exhaust steam from which can be utilized in the existing turbine or cylinders. If the exhaust steam from the additional unit has the same heat value as the live steam pressure in the existing plant, it is clear that the capacity of the prime mover has been increased by the amount of power developed by the additional unit, while its increasing energy will have been obtained with the smallest possible fuel consumption or practically the theoretical amount corresponding to the energy developed.

OBSTACLES IN THE WAY OF HIGH PRESSURES

Opinion has been openly expressed that the greatest difficulty in the application of high steam pressures would be the construction of suitable boilers. Little concern has been voiced as to the use of high pressure steam in reciprocating engines but doubt has been expressed as to the possibility of utilizing the extended range in heat in turbines due to the greatly increased losses in the blades. For-

[1]Abstracted from a paper presented at a joint session of Eng. Soc. of Western Pennsylvania and the Pittsburgh section of A. S. M. E.

*Chief-Engineer, The Superheater Co.

tunately, great progress has been made in eliminating the difficulties encountered in the design of high pressure boilers and turbines. The designs of valves and fittings have also so far advanced that they can be made suitable for enduring severe conditions in connection with high pressures.

Recent investigations of boiler materials have shown that heretofore important points were not sufficiently taken into consideration when selecting test-bars in the usual manner and making the tests for determining the strength. It was, for instance, found that the strength and composition of plates are poorer at the edges than at the middle. This is an important point in the case of plates for boiler drums, as the riveted seams are made along the weakest parts of the plate, that is, near the edge.

As regards elasticity the sectional horizontal water tube boiler has appreciable advantages. In comparison with other boiler types, this boiler retains a predominating position owing to its safety, facility of cleaning, possibility of standardizing, etc. It cannot be denied, however, that the sectional boiler in comparison with the vertical or semi-vertical type suffers from a serious defect, i. e., the restrained circulation, as the area of the headers and the circulating tubes between the headers and the drum is comparatively small.

For reasons of cost and design the size and number of drums of high pressure boilers (say above 1000 lb.) will be reduced to a minimum, which, in addition to the small tubes, makes the water and steam space of the boiler insufficient for the ordinary load fluctuations; it becomes, therefore, necessary to supplement the boiler capacity by some inexpensive and sufficient means for storage.

Fortunately, there is an excellent means available for the accumulation of energy up to any desired amount, namely, that of storing steam in water with increasing pressure and discharging it under falling pressure. The author figured, for example, a 1200-lb. pressure boiler with a 36-in. drum and found that at a peak load, the pressure in the boiler may drop as much as 300 lb. if it requires 5 min. for the boiler operator to adapt the supply of fuel to the stoker to suit the rush demand for steam. The provision of an accumulator between the high pressure and low pressure stages of the turbine will reduce the pressure drop to a permissible amount. By means of the accumulator, the water space is separated from the boiler and placed in a separate container in which the steam is accumulated and stored under pressure. At it is not necessary that the accumulator should be built to stand the high pressure of the boiler, full use can be made of the peculiar property of the hot water to accumulate much more steam at low than at high pressure for a given boiler pressure.

Superheaters Also Demand Attention

Development in superheaters has been along the lines which has made them adaptable to high pressures and high temperatures. Up to recent years superheaters in water tube boilers were located practically exclusively above the main bank of tubes or between the first and second gas paths. In this location, the temperature of the gases was sufficient for comparatively low superheat. The superheat obtained in this location varied with the rating of the boiler and at higher ratings, the superheat was higher, due to the increased amount of gases at a higher temperature, also the greater velocity of the steam. At low ratings, the superheat will drop. For low average superheat, these temperature fluctuations are of little consequence, as in any case the final temperatures are not excessive. With increased pressure and superheat, constant temperatures are imperative as any temperature fluctuations cause additional stresses in the prime mover which may become detrimental.

Due to the fact that the surfaces of a superheater are exposed to high temperature gases and depend for their cooling upon the flow of steam, internal stresses are occasioned in the superheater structure. This is aggravated by the fact that steam becomes a less ready absorbent of heat as it becomes superheated. No matter how properly a superheater may be designed, its service is always more severe and more likely to cause disturbance in operation than is the case of boiler design. This applies to any superheater, particularly, however, to those for modern boilers designed for high pressure and high temperature. An up-to-date superheater, adaptable to the present and near future requirements as to pressures and temperatures, must be so located that it is easily accessible so that it can be adjusted or inspected and boiler operation resumed in a minimum of time and at a minimum of cost.

It is a well-known fact that in any double or multiple cylinder reciprocating engine the high pressure cylinders are the most efficient, so that when high pressure steam is used, the higher the pressure, the higher is the efficiency of the first cylinders. The first tests made with high pressure steam were with reciprocating engines and remarkable results were obtained. In a four cylinder engine of 150 hp., the steam being resuperheated before entering the low pressure cylinder and expanding to 3 lb. abs., an indicated horsepower was obtained with 8220 B.t.u. The steam consumption was 5.22 lb. per horsepower; the initial steam being at a pressure of 800 lb. and temperature of 815 deg. F. or 294 deg. superheat and condenser vacuum 28½ in. The steam was resuperheated above the second cylinder to 600 deg. and above the last low pressure cylinder to 400 deg. Taking into consideration the live steam required for resuperheating, an indicated horsepower was obtained on 5 lb. of steam. These results are probably the best that were ever obtained with a reciprocating engine and can hardly be improved upon.

Conditions Which Affect Steam Turbines

With steam turbines, the conditions are reversed from that of reciprocating engines; the efficiency of the high pressure stages of the present turbines being considerably lower than that of the low pressure stages. Turbine designers themselves admit that a steam turbine, as a rule, will not work economically in the area of the higher pressure and for that reason they have tried to use the low pressure area to the best possible advantage by raising the vacuum to the utmost.

After it was established, however, that in reciprocating engines the advantages of high pressure are even larger than the theoretical consideration would indicate, turbine manufacturers were compelled to investigate means for increasing the efficiency of the high pressure stages in order to utilize the advantage of the higher pressures. In order to make it possible to design the high pressure area of a turbine with approximately the same high efficiency as that of the low pressure area, it is necessary to make the high pressure part independent from the other stages and develop it to a separate exclusive high pressure turbine.

If a perfect regenerative process could be employed for heating the feed, the efficiency of the cycle for saturated steam would be brought up to that of a Carnot cycle. In

such a process, the steam tapped off has been expanded doing work in the turbine down to the temperature at which it is required to heat the feed water. Since a certain amount of heat is required for this purpose, in any case, the work obtained from the tapped off steam is obtained merely at the expense of additional heat equal to the work done, or in other words, at 100 per cent efficiency. A slight practical objection to such a system of feed water heating is the additional complication of the pipe work involved, if a sufficient number of feed water heaters in succession are employed to approximate the thermodynamically reversible process; but even with two or three stages, considerable heat economy can be effected. The economical gain is due to the fact that the latent heat of the bled steam, which has already performed work, is absorbed by the feed water and returned to the boiler so that it is not wasted in the condenser.

The higher the feed water is heated by steam bled from the turbine, the higher must the air be heated in order to utilize fully the heat contained in the flue gases. Up to the present time there was considerable objection to having the air enter the furnace at high temperatures on account of the increased maintenance cost of the brick work. The recent tendency toward water-cooled walls eliminates this objection.

One advantage is not generally recognized. In the matter of turbine design there is an inclination to increase as much as possible the capacity of a turbine for a given number of revolutions; this is limited by the amount of steam that can pass the last blade wheel at a certain vacuum and at certain exit losses. By decreasing this amount of steam, the possible maximum capacity of the turbine is increased. With stage heating, the steam flow through the turbine is gradually decreased, thus decreasing the capacity limiting factor. This is the more pronounced, the higher the initial steam pressures, as for instance, at a pressure of about 1500 lb., 47 per cent of the steam must be bled from the turbine in order to heat the water to the maximum temperature.

Multiple Heaters Are Not Always Required

One new arrangement was recently suggested, wherein neither multiple pumps nor multiple heaters are required. The water to be heated is raised to a pressure sufficiently higher than the boiler pressure so that friction losses through the device will be taken care of. This may be done by a standard feed water pump. The feed line is gradually reduced in cross-sectional area to a small size and then gradually increased again to the original size of this pipe, similar to the reduction and increase of area in a Venturi meter. As in the Venturi meter, the operation of the device depends upon the law of hydraulics that the sum of static head, pressure head and velocity head at any point in a pipe line are equal to the sum at any other point, disregarding losses.

The section must be sufficiently reduced so that the pressure is less than the steam pressure of the lowest stage of the turbine from which steam is to be bled. The steam from this stage is introduced at this point and heats the feed water to the temperature corresponding to the pressure. At a point farther along the gradually increasing section the pressure, although higher than at the first point, is lower than the steam pressure of the next higher stage of the turbine from which steam is to be bled. This steam is then introduced, raising the temperature of the water to the temperature corresponding to the steam pressure.

Steam from as many stages of the turbine as desired is thus introduced at points along the increase in area, in each case the water pressure being less than the steam pressure, so that the steam from the turbine can enter and mix with the water. After the last point of introduction of steam, the area of the cross-section is still further increased so that the velocity head is transformed back to pressure head sufficient for the water to enter the boiler. With this arrangement, it is possible to heat the water by bleeding from many stages without undue complication as all that is necessary for each stage is a pipe connection provided with a check valve between the heater and the turbine, so that all advantages in connection with multiple stage heating can be obtained in a comparatively simple manner.

It may be worth while mentioning that this new development is now made public for the first time. A second method of increasing the mean temperature of heat reception is by resuperheating or adding further heat to the steam after it has passed a few stages and its temperature is reduced.

Probably the best known method of reheating steam is to install a secondary superheater in the boiler setting and then carry the steam from the turbine to the boiler and finally back to the turbine again. This arrangement, however, has many disadvantages, as the pressure of the steam for reheating is considerably lower than that of the live steam. The pipes carrying the steam to the boiler and back must be, therefore, of a large size which complicates the installation. While there are now superheater designs on the market which give fairly constant temperature at different ratings, some fluctuations are liable to occur, due to varying conditions in the furnace. The temperature drop of the steam in the turbine will, of course, vary depending upon the load. If the steam is sent back to the superheater installed in the boiler setting, we have a third variation, so that the total fluctuation temperature of the reheated steam may become serious. Another disadvantage of reheating the steam at the boiler, which is generally not recognized, is that there is a considerable distance between the boiler and the turbine so that the piping to and from the boiler will contain an appreciable amount of steam, which will flow to the lower part of the turbine even when the live steam is shut off by the turbine governor. This may cause overspeeding in case of sudden reduction of load unless a special governor is provided to control the readmission of steam contained in the piping to the lower stages of the turbine. A more simple arrangement is to reheat the steam in a separately fired superheater.

Two Reheaters May Be Used

In order to reheat the steam to a higher temperature than that of the temperature of live saturated steam, it was suggested that two reheaters in series be used. A rather unique method of reheating steam is to install a separate high pressure boiler room, the steam from which would be used only for reheating.

One of the most startling characteristics of high pressure steam is the advantage obtained by its use in prime movers, exhausting against a back pressure. By back pressure, I mean any exhaust pressure higher than that of the atmosphere. From the present back pressure engines with the usual comparatively low initial pressure, we can expect only a dilatory development for the reason that with the increasing back pressure, the greater part of the heat in

the steam available for work is withdrawn. If the initial steam is of a considerably higher pressure, however, then the heat withdrawn with exhaust steam is of less consequence. A study of the same relation between high pressure and back pressure reveals the fact that at back pressure, which occurs in practice, say up to from 100 to 160 lb. ga. the increase in the consumption of steam by a counter pressure steam engine per unit of energy (horsepower hour) will, at the live steam pressure above 400 lb., be only in direct ratio to the increase of the back pressure.

Ideal operation of a power plant is attained, of course, when as much exhaust steam as possible is utilized. With the present average pressure, this was found, however, to be of advantage only when the exhaust steam could be used at a comparatively low pressure, as for instance for heating or for cooking, or where a temperature between 200 and 250 deg. or a maximum of 300 deg. is sufficient. When exhaust of a higher temperature or pressure is required, it was not considered worth while to have the steam expanded in an engine as the amount of work that is obtainable is comparatively low.

It was also not considered worth while to combine large power stations with heating plants, as in central heating plants a higher pressure, say at least 80 lb., is usually required because the steam must be carried over a long distance. The combination of high pressure and back pressure offers new possibilities to combined power and heating.

Pipe Line Design Is Important

Pipe lines for high pressures must be designed so that any radical changes of direction are eliminated. Globe valves are, therefore, not suitable for high pressure boilers. Only gate valves with unobstructed passages and parallel seats should be applied. It is absolutely necessary that the disc moves freely, that means that it is pressed to the seat only by the pressure of the steam. The standard stuffing boxes have proven to be not sufficient for high pressure and high temperature. Also, the present packing material is not sufficient for high superheat. It is claimed that self-lubricating metallic packings with asbestos between rings are giving satisfactory results.

In view of the fact that it takes considerable time to heat up a pipe line to the temperature of high pressure steam, considerable condensation occurs in the line before it is heated up.

For feeding of high pressure boilers, only centrifugal pumps can be applied. By connecting the drain line into one of the stages of the pump where the pressure is lower than that in the pipe line, the condensate is forced into the pump where it combines with the feed water going to the boiler. The only disadvantage of this arrangement is: as the pressure in the pipe changes, the drain must be connected to different stages, so that the draining is not entirely automatic.

Appropriate metal for valve bodies is acid electric furnace steel. The better quality of acid electric steel is largely due to the maintenance of a reducing or non-oxidizing atmosphere within the furnace, resulting in a more nearly pure and completely degasified steel. Of considerable importance is also the proper and thorough annealing of the castings so that they may possess the best physical properties of which steel is capable.

Development of Mechanical Draft Equipment

Early Apparatus Was an Adjunct to Plant, Now a Necessity. Modern Practice Necessitates Rugged Fan Construction. By C. A. Booth

ENGINEERS ARE often brought to realize that they are constantly rediscovering old facts or principles; the history of the use of mechanical draft is a good example of this. We must go back beyond the day of Watt to find the first blowers used for melting grey iron in the cupola, and the old natural draft stacks for smelting iron ore remain only as a curiosity in some out-of-the-way corner of the world. In the cupola and the blast furnace, forced draft is the very essence, the moving force of the process, without which the age of steel would never have arrived.

Mechanical draft, however, in the ordinary meaning, applies to steam boilers, and this is what we have in mind. In spite of what might almost be called the antiquity of the use of air under pressure for increasing the combustion rate, the engineering world less than a generation ago regarded it as a makeshift, a substitute or a means of temporarily increasing the steam capacity—anything, in fact, but an essential part of a boiler plant, to be considered and provided for at its inception.

On shipboard, obliged by limited space to keep down the dimensions of the boilers, engineers used forced draft, either with a closed stoke hole or with the Howden system, for increasing the rate of steaming and thus getting more work out of the boilers, but while this practice became common in 1885, the name "forced draft" still seemed to convey the idea of something undesirable and unnatural, to be avoided at no matter what cost, in favor of our reliable old friend "natural draft."

In the literature of 25 yr. ago on this subject, we find that the principal arguments advanced in favor of mechanical draft were, (1) the ability to burn cheap fuel, though the best of fuel in those days was so low priced that it hardly paid to ship the poorer grades, (2) the assistance to poor draft or to a boiler already doing all it could and (3) its low cost compared with that of a stack. At that time boilers were made in units which seldom exceeded 200 hp. Stokers were just beginning to come into use in the larger power plants but, in general, hand firing was still the order of the day.

Early Types of Blowers

At that time, the New York Edison Co. was in the first stages of experimenting with forced draft for burning buckwheat coal in a large central station, and the blower units employed, although large in comparison with most of the forced draft installations of those days, were small indeed compared with even an ordinary one today. The blowers were steel plate paddle-wheel fans driven by direct-connected, high-speed, vertical engines at about 300 r.p.m. Underfeed stokers were then new, and as most of the boilers were hand-fired and in small units, it was customary to use a single blower for forced draft with a duct branching into each ashpit and a damper or blast gate with the operating lever convenient for the fireman's use. Naturally, since these systems were frequently used to help out bad chimney draft, the principles of balanced draft were seldom observed and air pressure above the grates

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made it dangerous to open the fire doors. Few owners had any idea of operating boilers beyond the nominal rating, so that draft pressures, except in cases of badly designed flues or chimneys, were limited to 1¼ in. to 1¾ in. of water.

The average boiler plant at that time consisted not only of smaller units, but also had a much smaller total capacity. The transportation problem even in the large cities was not complicated, the trolley systems were small and poorly patronized, and great organizations and capital had not combined them into groups, while long distance

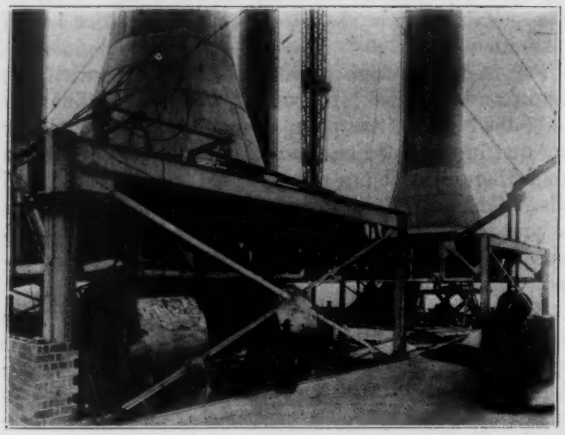


FIG. 1. INDUCED DRAFT FANS PARTLY INSTALLED AT MARYSVILLE STATION

electrical transmission lines were unheard of. The 25-mile line from Niagara Falls to Buffalo was a marked advance in this branch of engineering, and the present superpower plant, delivering energy over a radius of 100 miles, had scarcely reached the point of being an inventor's dream.

Yet all these things were in the air, and with the new century began the growth of the public utility; first the street railway, then with it the central heating station and the universal domestic use of electricity for all purposes. The seriousness of the load fluctuations attending this kind of service was recognized and special consideration taken in the design of plants for peak load conditions. Boilers were designed in larger sizes for rapid steaming and to accommodate stokers which, with forced draft, could operate efficiently over a wide range of combustion rates. Higher steam pressures and boiler temperatures were more widely used, the concurrent development of the steam turbine being not the least factor in the growth of such plants.

Air Pressures Increase with Station Development

At first the type of blower used for forced draft continued the same, but the improvements in small steam turbines on the one hand and the increasing use of motor-driven accessories in the power plant on the other were bringing increasing pressure to bear for the use of higher speeds and, just as the centrifugal pump largely superseded the reciprocating type, the high-speed multiblade fan sent the old engine driven units into the discard.

These fans occupied much less space and the difficulties which were first experienced in operating multiblade fans in parallel were soon overcome by the use of new blade forms, which changed the pressure-volume characteristic curve and at the same time required higher speeds, bringing the fan speeds nearer to those of the motors which furnished the commonest method of drive. Plants began to be designed with underfeed stokers and forced draft in which the boilers were operated at double the normal rating or more, combustion chambers increased in size and height and sizes of turbo-generator units increased by leaps and bounds from 5000 kv.a. to 50,000 kv.a. and larger, any one of which, only a few years before would have exceeded the capacity of the largest power plant in the country.

So long as the boiler units remained of comparatively small size, it was customary to use one or two forced draft blowers, supplying an entire battery of boilers through a trunk duct. More and more frequently, however, it became the practice in the design of boiler plants to make each section complete in itself, and at present it is the rule for each boiler to have its own forced and induced draft fans. This has tended in the larger stations to limit the range of operation by running each boiler more nearly at constant load and putting additional boilers on the line for peak loads. However, the economy in cost of building and equipment and the improvement in operating efficiency at high combustion rates have fixed the usual operating load at about 200 per cent of boiler rating. The

FIG. 2. STOKER FANS AND AIR DUCTS

present standard practice in stoker-fired plants calls for the use of a forced draft blower operating most of the time at pressures from 3 in. to 4 in. of water, but with variable speed drive and capable of furnishing blast pressure at from 6 in. to 7 in. Constant speed motors and damper control for blast pressure, although less economical, have been used particularly where the variation in load conditions is small. These blowers are often cross-connected to supply air for the boiler on either side and run at something less than the maximum load.

These comparatively high pressure blowers resemble in no way the old-time line of forced draft fans, but have large bearings whose pedestals are mounted directly on foundations, the shafts and rotors being built for speeds of 1200 to 1800 r.p.m. or more, and housings carefully proportioned to reduce the losses in handling air at high velocities. Formerly located on the boiler room floor, and then in the basement, forced draft fans are now frequently placed above the boilers. This indicates the tendency to grow not only in size of units, but in height.

Many Small Plants Now Use Mechanical Draft

Even the small plant has changed in many respects, dependence on natural draft alone now being the exception rather than the rule. Small motor-driven blowers are now used not only in industrial plants, laundries and apartment houses, but are even becoming common with domestic heaters, where their convenience, low operating cost and dependability recommend them to the house owner. With such a blower there is the same advantage in getting a hot fire quickly that the large plant possesses in meeting a peak load.

Many attempts have been made to design a steam locomotive with fan draft. Such a system, when perfected, as eventually it may be, would not only have the advantage of being more economical than the use of the exhaust for producing draft, but would be more uniform and easily controlled. The amount of fuel required would be decreased, and with it the labor and expense of handling. The development of the disk or propeller type of fan for use against pressures of more than ½ in. of water gives hope that the difficulty in the way of fans for locomotive draft—namely, lack of space—may yet be surmounted.

As the propeller type of fan is essentially a high-speed machine, it lends itself well to steam turbine drive. One

FIG. 3. PHILO STATION USES DOUBLE INLET INDUCED DRAFT FANS

development in this direction has been the undergrate blower, which has become popular particularly for small isolated steam plants where the boiler units are not over 200 or 250 hp. The undergrate blower consists usually of a single-stage impulse turbine with ball bearings and a propeller wheel mounted in a cast-iron sleeve or drum which sets into the ashpit wall. This type of fan is less efficient than a multiblade or other housed centrifugal fan, and the turbine itself is not particularly economical, but the steam used by these undergrate blowers is probably only 1/3 to ¼ of the amount required to operate a steam jet for draft.

Assuming that mechanical draft equipment must be in continuous operation, the amount of power required to operate a boiler at normal rating corresponds to 10 per cent of the total steam generated for a steam jet, 2 to 3 per cent for a turbine-driven propeller fan, and 1 to 2 per cent for a housed centrifugal fan.

When combustion rates were going higher and higher and increasing thickness of fuel beds required more and more air pressure to insure the necessary volume, other changes in boiler design for large plants were being made which at first greatly increased the height of stack necessary, until it passed the stage where natural draft was a possibility. Extra baffling in the boilers and the use of superheaters and economizers increased the resistance to the flow of gases, and the effect of the economizer was to reduce the amount of draft available by bringing the stack temperature down from 550 deg. to 350 deg. The type of induced draft apparatus which proved best suited for these conditions was the multiblade fan, but instead of the old tall, narrow housing, a double width, double inlet arrangement was used, with gases entering at each side through intake boxes connected as directly as possible

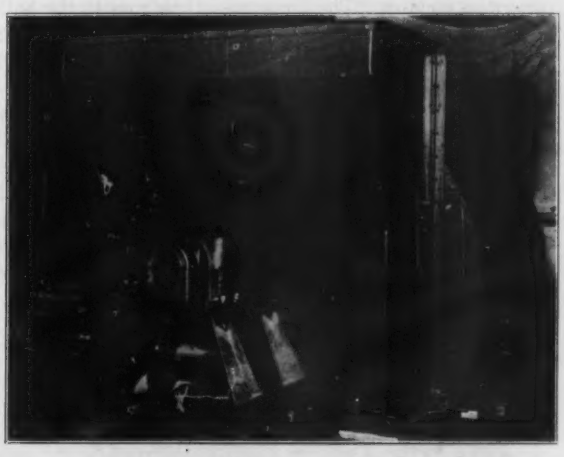


FIG. 4. FORCED DRAFT BLOWER HAS RUGGED CONSTRUCTION

to the uptake from the boiler. A fan of this type with its intake boxes has approximately the same overall dimensions as the width of the boiler itself, and fits in very nicely with the steel work. It requires little headroom and operates at a speed which renders it suitable for direct connection to motors.

These units are unlike the old type of induced draft fan, but so are the conditions dissimilar. Instead of merely drawing the products of combustion over the tubes at a moderate rate, the duty is no less severe, in fact even more exacting, than for the forced draft blowers. From a draft pressure of 1¼ in. of water, it has crept up until present design calls for a fan to be able to maintain a pressure difference, depending on load conditions, of from 3 in. to as much as 8 in.

These relatively high pressures, with flue gases at 300 to 400 deg. F., means that the fans must be heavy, substantial, ultra-reliable pieces of equipment. Instead of a light blast wheel overhung on the end of the shaft, rotors of heavy plate construction with blade forms of inherent strength are used, mounted on massive shafts twenty or more feet in length extending through the intake boxes and carried in water-cooled bearings. Operating speeds, due in part to the increased draft required and in part to changes in the type of fan found most suitable for this work, have gone from 200 to 300 up to 500, 600 and 700 r.p.m. and above. To cover a range in load with good efficiency two motors are often used, one for the higher speeds and, at the other end of the shaft, a second motor of much less horsepower for the low part of the range, only one motor being energized while the other is idling on the shaft.

Air preheaters are now installed in some of the largest central stations, and their performance is being watched with interest. Here again the idea is not new, as hot

blast has been used in smelting ore for more than a generation, and in marine boiler practice for fully that length of time. As applied to stationary plants, preheated air has been tried out experimentally without marked success, but present day conditions seem to indicate its desirability.

When steam is bled from the main turbines at intermediate stages, a sufficient amount of heat is thus obtained so that the useful range for a feed water economizer becomes limited and its installation of doubtful value. For such cases the air preheater affords the means of recovering from the flue gases the heat which the economizer would otherwise reclaim. The air supply thus goes to the boilers at temperatures between 150 and 175 deg., instead of the year round average of about 70 deg., tending to improve the

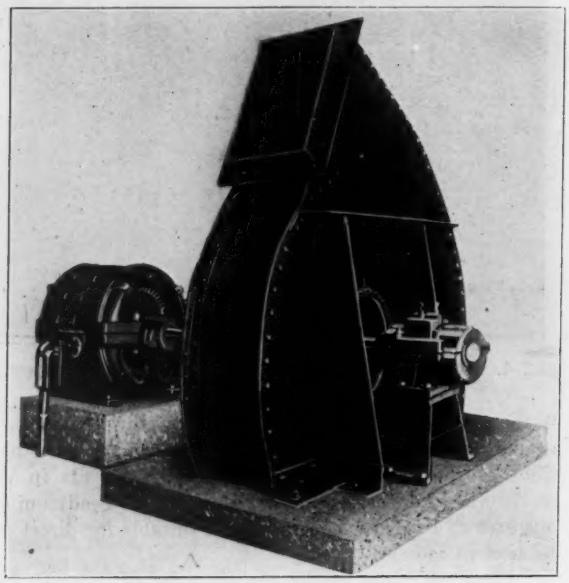


FIG. 5. BLOWER USED WITH PULVERIZED COAL SYSTEM

efficiency of combustion and to increase the capacity of the boiler. We will soon be in a position to know under what conditions the use of air preheaters should be recommended.

These developments have been so rapid and are of such recent date, that no one familiar with them would venture to predict that what we are doing now will not be out of date in a few years. When plants which were designed for 100 per cent excess capacity are overloaded before they can be put into operation, it is a wise engineer who can be enough of a prophet to know what is coming in combustion practice. But, given the demand, we will undoubtedly see the means provided to meet it.

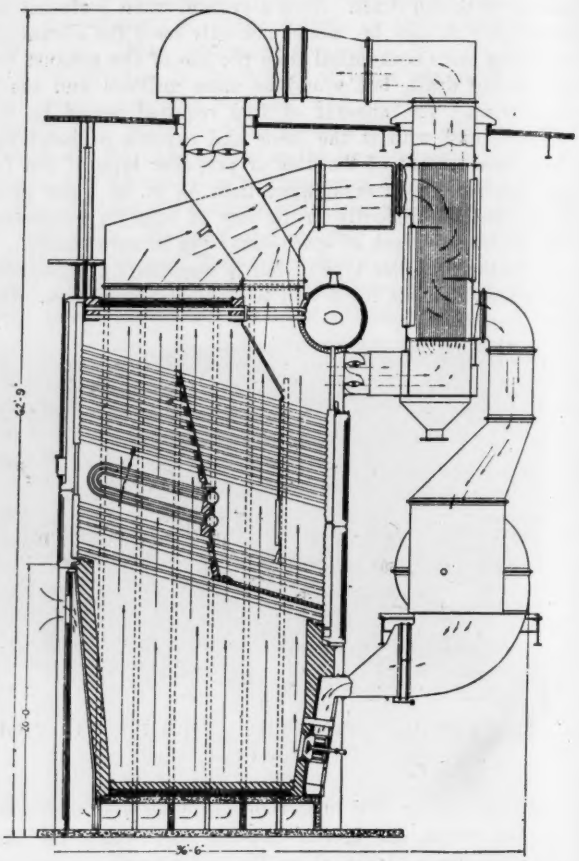
Correction Note

OUR ATTENTION has been directed to an error in the article "Purification of Feed Water Containing Oil" by C. E. Joos, which appeared in the December 15th issue of Power Plant Engineering. A sub-head, reading "Over-Heating of Metal" was omitted from the bottom of the second column on page 1245 immediately following the sentence ending, "other effects outlined herein." This omission as will be noted detracts from the sense of the first sentence of the next paragraph since it is dependent upon the omitted sub-head for its meaning.

Oil Burning in Stationary Power Plants

STEAM AND MECHANICAL ATOMIZING; HEATING THE OIL; FURNACE VOLUME AND ARRANGEMENT. FROM A PAPER PRESENTED BEFORE THE A. S. M. E. BY NATHAN E. LEWIS

FOR MODERATE sized plants and where the load is reasonably steady so that the boilers are not called on for extreme overloads, the steam atomizer is used and has



IN THIS INSTALLATION, WALLS ARE COOLED BY AIR AND THIS AIR IS FURTHER HEATED FOR SUPPLY TO THE OIL BURNERS

certain advantages. At rated load, it operates with moderate draft; it is simple and easy to keep in repair; oil to supply it can be at lower pressure and temperature than for mechanical atomizers, 130 to 190 deg. F. and 40 to 60 lb. It gives, however, a long, flat flame which must have room so that it will not touch the furnace walls or boiler heating surface; its capacity is 1200 to 1300 lb. of oil an hour per burner, the maximum capacity to which the boiler can be worked being 200 per cent of rating; furnace volume required is but 0.15 cu. ft. per sq. ft. of heating surface or 0.35 cu. ft. per lb. of oil to be burned per hour. Air supply is through a false floor of brick checker work, the pattern and arrangement of this checker work having considerable influence on the effectiveness of the operation. This makes use of more than one row of burners impossible.

Mechanical atomizers are generally used where a heavy overload is to be carried and maximum capacities are desired. The mechanical burner will operate a boiler at as high overload as a coal-fired furnace; it will burn 1500 to 1600 lb. of oil an hour and can go higher, if sufficient draft and blast are furnished; it gives a short conical flame and can evaporate as much as 10 lb. of steam per square foot of heating surface and as much as 60 lb. per cubic foot of furnace volume. On the other hand, the oil should be heated to 200 to 280 deg., which requires live steam, and the oil is handled at 100 to 250 lb. pressure; also a higher draft must be furnished than for steam atomization. Furnace volume must be provided of 0.5 cu. ft. per sq. ft. of heating surface or 0.5 cu. ft. per lb. of oil to be burned an hour. The high temperatures resulting from high rate of combustion make the problem of furnace wall maintenance difficult. Air is supplied around the burner itself, the position of the impeller plate through which the air comes having a considerable effect on the efficiency of the burner, but allowing of the use of two rows of burners in a boiler, staggered vertically.

Oil Must Be Heated

In heating the oil, care should be taken that it is sufficient but not too great. Low temperature results in poor atomization and a smoky fire; too high temperature results in waste of steam, pulsations of the flame and a lowered capacity of the burner. With steam atomization, exhaust steam can be used for heating the oil and the heating apparatus need be tested only for 150 lb. on the oil side and 60 lb. on the steam side; for mechanical atomization, live steam is necessary for heating and both oil and steam sides of the heater should be tested for 250 lb. The heavier the oil used, the higher the temperature to which it must be heated to work satisfactorily.

Extreme care must be taken to get pipe lines carrying oil tight as the oil is difficult to hold at the joints and a small leak may produce a big fire hazard. It is necessary, therefore, to have the piping of ample size, to use long-radius bends and to keep the number of joints down to the least possible, providing valves to isolate sections for repairs when needed.

Because of the high temperatures carried in oil-burning furnaces, it is essential to have the best possible furnace walls and to cool them as much as possible. Two methods of cooling have been proposed and tried; air circulation in hollow walls and setting boiler tubes in the walls to carry away some of the heat. Even then, the best quality of fire brick is needed which can be had only by careful selection, this, of course, resulting in higher cost, though the quality of fire brick is being improved by manufacturers in response to the demand. Most brick will undergo plastic deformation under 25 lb. pressure per sq. in. and 2400 deg. F. temperature or under 10 lb. pressure and 2600 deg. As furnace brick is often under 15 lb. pressure and furnace temperatures run as high as 3000 deg., it is evident that only the best brick will serve. Small volumetric changes in the brick, due to expansion and shrinkage, will result in bulged and cracked walls and larger changes, in spalling.

One form of air cooling which has been tried is shown in the illustration. It is an installation made by the Babcock & Wilcox Co. for the Houston (Tex.) Lighting and Power Co. Air from a point about 17 ft. above the boiler room floor is passed down through ducts back of the rear wall of the furnace and under the floor to ducts back of the side walls. It rises through these and a breeching to an air heater whence it is drawn by a fan and delivered to the oil burners. This unit has 19,884 sq. ft. of heating surface, 11,660 sq. ft. of air heating surface, rated capacity of 150,000 lb. of steam an hour and evaporation, at rating, of 7½ lb. of steam an hour per square foot of heating surface. The experience with this type of cooling is encouraging but not sufficient to warrant definite statements as to its economy.

Features of Airless Injection Oil Engines---V*

Description of a Solid Injection System Wherein the Fuel Pump Is Acted Upon by Air in the Power Cylinder. By H. F. Birnie and R. C. Baumann

ARSCHAOULOFF'S system is one of the newer developments of the solid injection problem. The main difference which distinguishes this system from the usually adopted solution, is that the fuel pump is not driven from the cam, or crank, shaft through roller and cam, but is acted upon by the air in the power cylinder during the compression stroke.

Referring to Fig. 1, showing a layout of the arrangement, we see a fuel impeller, 1, driven by a small impulse piston, 2, the latter being in open communication with the working cylinder A. The ratio between the areas of the impulse piston and the fuel impeller determines the pressure of the fuel oil going to the spray nozzles.

An auxiliary pump under hand or governor control measures the fuel and delivers it into the chamber, 3, during the suction or scavenge period, i. e. when the pressure acting on, 2, is small (or even negative) thus encountering but slight delivery pressure just high enough to push back the impeller, 1, and the impulse piston, 2.

From the chamber, 3, fuel is delivered through a small pipe to the differential valve consisting of a needle, 5, a tension spring, 9, and an auxiliary spring, 6, which is under control of the engineer through a lever, 7, and permits him, while running, to vary the tension on the fuel needle. Increasing the tension of the needle will mean:

1. A higher fuel pressure necessary to open the valve.
2. A better atomization.
3. A smaller "lead" as the valve will open later.
4. A decrease of the maximum burning peak. It should be remarked that, due to the resulting better atomization, the lowering of the burning peak did not, in this case, have as consequence a smaller mean effective pressure, nor an increase of the exhaust pressure.

Arschaouloff's system is attractive because of its simplicity and freedom of all vibration. It embodies practically all the requirements of the solid injection problem and permits the conversion of the air injection Diesel to the solid injection engine at minimum cost.

For instance, the conversion of a four-cycle air injection Diesel would require:

*Part I appeared in the July 15 issue, Part II in the October 15 issue, Part III in the November 15 issue and Part IV in the December 15 issue.

1. Taking off the compressor and substituting a small auxiliary compressor to fill up the starting air bottles only.

2. Discarding: The injection air receiver—the fuel cams and cam rocker arms—the injection air piping—the fuel valves.

3. Shortening the bed plate by the length occupied by the compressor.

4. Slightly changing the pattern of the cylinder head to permit the drilling of the connection to the impulse piston and machining a recess for the latter.

5. Taking off the shims under the working piston connecting rods to lower the compression to about 380 lb.

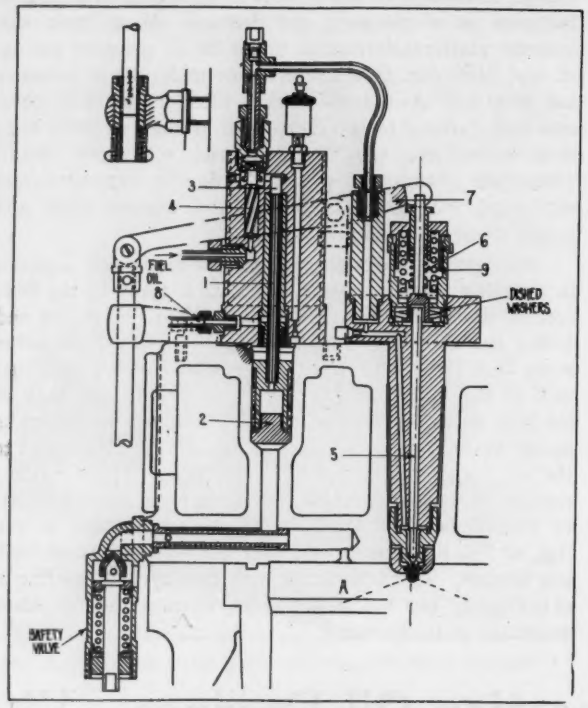


FIG. 1. IN THE ARSCHAOULOFF SYSTEM THE FUEL PUMP IS ACTED UPON BY THE AIR IN THE POWER CYLINDER DURING THE COMPRESSION STROKE

This system works in the following way: As the working piston comes up to its compression stroke, the pressure inside of the cylinder acts on the piston, 2. The plunger, 1, and the piston, 2, having, for instance, a ratio of areas of 1:13, the pressure on the fuel oil in the chamber, 3, would be (admitting a compression end pressure of 380 lb.):

$$13 \times 380 = 4940 \text{ lb.}$$

But, the fuel injection period has to be given some lead, and if we choose the valve to open at 360 lb. compression, we find that the pressure in the fuel line will then be

$$13 \times 360 = 4680 \text{ lb.}$$

This pressure being sufficient to give a good atomization. The differential area of the fuel needle times the pressure of the oil, will then determine the size of the spring holding down the needle of the differential valve. The lead of the fuel injection is thus under control of the designer and, while running, of the engineer who can vary it, to a certain extent through the rod, 7, and the additional spring, 6.

As soon as the fuel begins to burn, the pressure in the power cylinder is raised from 380 to about 550 lb. This increased pressure acts of course on the piston, 2, and the fuel is delivered with increased speed and pressure. Consequently the fuel needle is positively lifted to its full measure, in contrast to the variable lift of the Hesselmann differential valve. This condition has the advantage of reducing the throttling losses at the needle seat.

Closing of the fuel valve occurs at a predetermined pressure fixed by the construction of the fuel valve. This pressure can be kept sufficiently high to prevent a coarsening of the spray.

At the end of the injection period, the gases expand in the combustion chamber and the pressure acting on the impulse piston, 2, will decrease, permitting the fuel oil in the valve and the piping to expand backward, thus preventing any leakage at the fuel needle seat during the expansion stroke.

During the suction or scavenge stroke of the engine, the auxiliary fuel pump delivers the fuel to the chamber, 3, through the suction valve, 4, under a pressure which has only to be sufficiently high to push back the piston, 2, and plunger, 1.

As, during this period the pressure in the cylinder is minimum, the work done by the auxiliary pump is small, thus requiring but small forces from the governor.

Finally, reversing of the fuel pump (necessary for big marine engines) is automatic. The spray valve opens at a certain compression height whether running forward or reverse.

Arschaouloff has given an elegant solution to the solid injection problem. It does not give much room for criticism and the few doubtful points of the system have proven themselves to be quite unfounded in actual practice. Its one outstanding feature is its absolutely noiseless running.

Referring back to Fig. 1, one sees that there is a lost air volume (i. e. not used for combustion purposes) between the opening A and the piston, 2. The air volume to the safety valve should not be included in this loss, and one sees readily that the actual dead air volume can be kept small. The design of the impulse piston, 2, permits a light construction and its inertia can be minimized so that there are no restrictions for its use on high speed engines. The passage between the piston, 2, and the combustion chamber is scavenged by means of a snifter valve after each firing stroke. On the newer designs the lubricating oil drilling to the piston, 2, opens between the piston rings instead of being lubricated from the top by a sight feed oiler as in Fig. 1.

There were misgivings, at first, concerning the piston, 2. It was feared that the heat from the combustion chamber would tend to gum up the piston rings but, even after the longest continuous runs there has never been found a trace of sticking piston rings.

Plunger, 1, and piston, 2, are self-alining. Fuel leaks past plunger, 1, and is drained off through the opening, 8.

Pressure losses between the impulse plunger, 1, and the differential valve are small due to the short pipe connection. Air contained in the fuel line can be removed by a drain situated at the highest point of the fuel line.

Small variations of lead and fuel oil pressure are taken care of by the auxiliary spring, 6. The differential valve does not include delicate parts outside of the spray tip, a fact that will be appreciated by engine operators in the field.

Indicator Cards Show Good Regulation

Figure 2 shows a number of indicator cards taken with Arschaouloff's injection system. Card No. 1 shows a full load card, indicated m.e.p. = 104 lb. Card No. 2 is a series of 22 cards taken on the same diagram illustrating the close regulation and fuel burning conditions. The other four cards were taken while tightening down gradually the auxiliary fuel valve spring, 6, showing the lowering of the combustion peak pressures from 625 to 611 to 576 and 540 lb. The indicated m.e.p. remain about constant being respectively 93.7—95.2—91.0—92.4 lb. per sq. in. The exhaust pressures do not show any appreciable variation.

Werkspoor Co. has made an interesting study of an indicator card taken on its four-cycle experimental engine, bore 12.6 in., stroke 17.7 in., r.p.m. 250 and the discussion of this diagram illustrates clearly the process of combustion of the Arschaouloff injector. Figure 3a shows a normal indicator card the mean indicated pressure being 104.2 lb. The lead of the fuel injection is 15.5 deg. and the end is 21.5 deg. after dead center for a total angle of 37 deg. as measured on the flywheel.

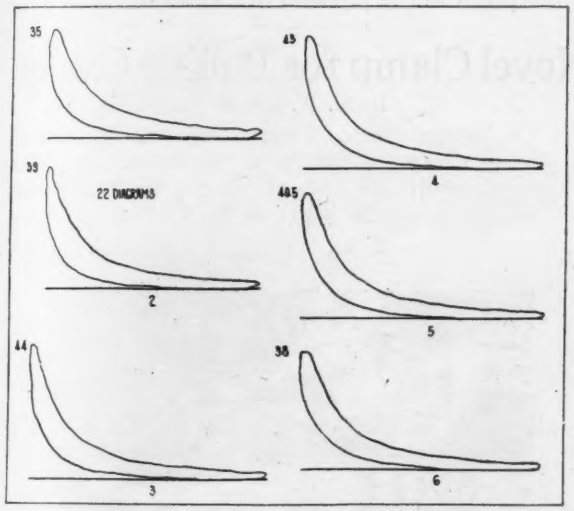


FIG. 2. GROUP OF SIX INDICATOR CARDS TAKEN OF THE ARSCHAOULOFF SYSTEM UNDER VARIOUS CONDITIONS OF OPERATION

Figure 3b shows a diagram of the fuel pump plunger movement. The points of the card can all be plotted back on the circumference of the circle below the normal indicator card. In this way the beginning and end of the fuel delivery can be traced back on the normal and offset diagrams.

Point a is the beginning of the fuel delivery and c the end. The movement of the plunger during the injection period is continuous. If the points 1 to 10 of the crank circle are plotted on a straight line and the corresponding points of the pump diagram brought up on ordinates, one sees that the plunger movement is nearly at constant speed, Fig. 3c.

Referring back to Fig. 3b point d corresponds to the exhaust dead center, e, to the end of the exhaust stroke, g to the intake bottom dead center and k to the compression upper dead center. The movement of the fuel pump plunger from h to a represents the volume taken up by the pump plunger while the fuel oil and the gases it contains is being compressed from atmospheric pressure to the point of opening of the fuel valve, in this case 3700 lb. per sq. in. This volume will of course vary with the fit of the fuel pump plunger and the grade of the fuel oil.

Beginning of the fuel injection is marked by the sharp break of the curve at point a, Fig. 3b. The sharpness of this break shows that the fuel valve opens quickly, as can be expected on account of the additional surface of the fuel needle coming under the action of the fuel oil pressure when the needle begins to lift. In other words a pre-

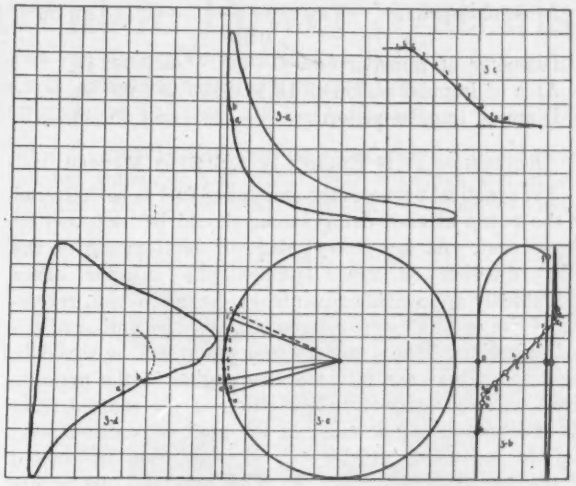


FIG. 3. NORMAL INDICATOR CARD AND STUDIES OF FUEL PUMP PLUNGER MOVEMENT, AND THE FLARE OF THE INITIAL FUEL CHARGE

dripping of the valve due to a sluggish opening of the valve does not exist.

At the end of the delivery the plunger movement is slowing down during a short time, approximately 0.005 of a second, while the fuel valve closes between points c to c_1. After the closing of the valve, the plunger recedes gradually as the pressure in the working cylinder lowers and the fuel expands.

Figure 3b shows also that the auxiliary fuel pump delivers the fuel during the air intake stroke of the engine, i. e. while there is but a slight negative pressure acting on the impulse piston. Two special points a and b of the diagrams are remarkable. Between these two points, situated on the compression line, the curve drops slightly. This drop can be attributed either to the chilling effect of the entering spray or to the increase of combustion chamber volume by the upward movement of the impulse piston, or to both causes simultaneously. Point c indicates the flaring up of the initial fuel charge, as shown by the sudden rise of the pressure in the diagram Fig. 3d.

The Arschaouloff injector can be calculated in the following way:

Engine dimensions: Bore = 12.6 in.
Stroke = 17.7 in.
R.p.m. = 250
Compression = 380 lb.
Type = 4-cycle.

From the indicator diagram we take:
Indicated m.e.p. = 104.2 lb.
Thus: indicated horsepower = 72.7

Assuming further a fuel consumption of 0.3 lb. per indicated horsepower, we find

$$72.7 \times 0.3 = 21.8 \text{ lb. fuel per hr.,}$$

or: $$\frac{21.8 \times 231}{60 \times 125 \times 7.5} = 0.0895 \text{ cu. in. per firing stroke.}$$

Roughly the fuel pump has thus to deliver:

0.09 cu. in. of fuel at each upward stroke.

Assuming a stroke of the fuel impeller of 0.59 in. and a ratio of 1:13 between the areas of fuel impeller and impulse piston, the pump dimensions are set as follows:

$$\text{Area of impeller} = \frac{0.09}{0.59} = 0.153 \text{ sq. in.}$$

$$\text{Diameter of impeller} = = 0.442 \text{ in.}$$

$$\text{Area of impulse piston} = 13 \times 0.153 = 1.99 \text{ sq. in.}$$

$$\text{Diam. of impulse piston} = = 1.59 \text{ in.}$$

Reversing This Engine Is a Simple Matter

For practical purposes the amount of fuel to be delivered by the pump at each firing stroke should be increased by 10 per cent. At the present stage of development of the solid injection engines, Arschaouloff's injector offers undoubtedly appreciable advantages. As mentioned, reversing of the engine reverses automatically the timing of the fuel injection. The auxiliary fuel pump can be timed in such a way that a rotation of the engine in the opposite direction does not require a shifting of the cams driving it. Its location can be made at the most convenient point and the measuring of the fuel oil is accurate on account of the low fuel pressures. In high pressure fuel pumps measuring the fuel by means of a bypass valve opening against a high pressure obviously make it difficult to cut off accurately a stream of oil flowing with great velocity to the spray valves. This stream has to change its course suddenly but as a rule the beginning of the bypass valve opening is not rapid, and besides it is of rather small area.

Engines using the common rail system regulate the flow of oil by varying mechanically the lift of the fuel needle and this method gives accurate measurements. Its drawback is that at light loads the throttling losses between the fuel needle and its seat are great. This objection is obviated in Arschaouloff's system, the lift of the fuel valve being constant.

Referring to Fig. 1, it will be observed that the piston, 2, is stopped on its upward travel by an air cushion which acts as soon as the first piston ring covers the small vent hole to the top of the cylinder head. Some other designs prefer to have a metallic stopping surface.

Limitation of the lift of the differential valve is done in different ways. Some designs use a plain set screw, others employ a set of 4 dished steel washers which are located at the end of the fuel needle and are put in without tension. As soon as the valve lifts the washers are compressed and their deflection should correspond to a predetermined value. This lift is kept small, between .040 in. and .050 in., so that the tension spring, 9, is practically uniformly loaded, insuring an indefinite life to the spring.

Suction valve, 4, is of a peculiar design, generally not adopted in the existing solid injection engines. Its advantage lies in the fact that its length provides good guiding condition and accurate seating.

It has been noticed by the reader that Arschaouloff has not taken means to insure an increased turbulence. While being rather in favor of a directed air flow as in Hesselmann's system, it remains a fact that engines using high fuel pressures, 3000 to 7000 lb. and higher, do not require it, the better fuel atomization being chiefly responsible for this condition.

As for the combustion cycle obtained with this system it is of the mixed Otto-Diesel cycle, as in most solid injection engines. Before closing the description of this system, it should be mentioned that its inventor has added to it a patented feature which permits scavenging the holes of the spray tip. Operators of solid injection engines know from practice that after a certain length of time, the exhaust of the engine which was clear at the beginning of the run, gradually becomes smoky. They know then, that it is time to put in the spare nozzles and clean those which have been taken out. The smoky exhaust is due chiefly to the clogging of the spray holes with carbon.

Air injection Diesels offer in this particular point the advantage that the nozzle openings are always scavenged with air under pressure.

The solution adopted by Arschaouloff to scavenge the spray tip of his injector with compressed air is simple and does not require any additional features. A description of this patent will be published in a subsequent issue.

Novel Clamp for Pulling Cables

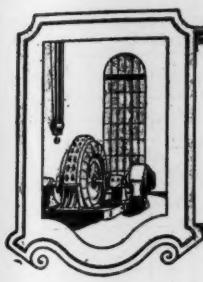
By C. W. Geiger

In THE accompanying photograph is shown a novel and efficient clamp designed by a foreman of the Great Western Power Co. for use in attaching a wire rope to the end of one or several power cables for pulling them

FIG. 1. ONE MAN CAN ATTACH THE CLAMP TO THE END OF A CABLE IN A FEW MINUTES

FIG. 2. SHOWING CONSTRUCTION OF CLAMP

through a conduit under the street. The clamp is slipped over the end of the power cable and then wrapped with wire at four places as shown in Fig. 1. The clamp is so designed that when the end is pulled by the wire rope the clamp grips the power cable so firmly that it cannot possibly slip off the cable neither can the clamp injure the end of the power cable. It can be applied by one man in a few minutes and can be used in pulling one or several power cables.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Control of Wattless Current in Power Systems*

AMONG THE MOST IMPORTANT PROBLEMS OF THE POWER COMPANIES ARE THOSE DEALING WITH THE REGULATION OF THEIR TRANSMISSION LINES AND THE CONTROL OF WATTLESS CURRENT ON THEIR DISTRIBUTION SYSTEMS. BY S. Q. HAYES†

POWER DISTRIBUTION and transmission companies have many problems to solve and among the more important ones are those dealing with the regulation of their transmission lines and the control of the wattless element on their distribution systems. These problems are both

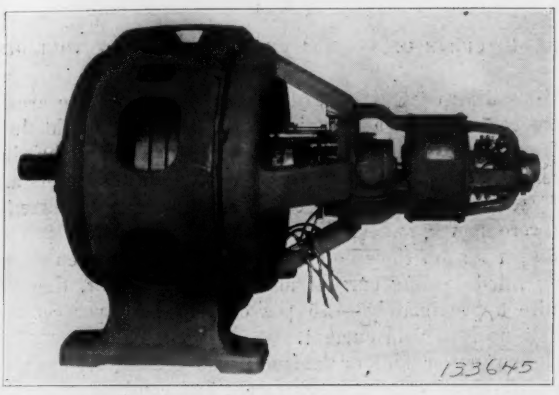


FIG. 1. A 150 HP. 1200 R.P.M. BRACKET TYPE SYNCHRONOUS MOTOR WITH DIRECT CONNECTED EXCITER

phases of the same general problem of power factor improvement.

With alternating current transmission there is a voltage drop resulting from the resistance of the conductors which is in phase with the current. In addition there is a reactance voltage drop, that is, a voltage of self-induction generated within the conductors which varies with and is proportional to the current and may add to or decrease the line voltage. If the line is long, the frequency high, or the amount of power transmitted large, this induced voltage will be large, influencing greatly the line drop. By employment of phase modifiers, the phase or direction of this induced voltage may be controlled so that it will be exerted in the direction that will result in the desired sending-end voltage.

A certain amount of self-induction in a transmission circuit is an advantage, as it allows the voltage at the receiving end to be held constant under changes in load by means of phase modifiers. It may even be made to reduce the line voltage drop to zero so that the voltage at the two ends of the line is the same for all loads. Self-induction also reduces the amount of current which can flow in case of short circuits, thus tending to reduce mechanical strains on the generator and transformer windings and making it easier for circuit breaking devices to function successfully. On the other hand, high self-induction reduces the amount of power which may be transmitted over a line and may, in case of lines of extreme length, make it necessary to adopt a low frequency. It also increases the capacity of phase modifiers necessary for voltage control.

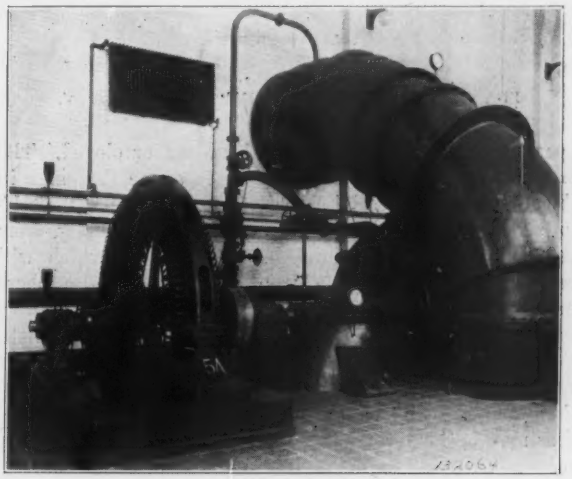


FIG. 2. A 450 HP. 106 R.P.M. SYNCHRONOUS MOTOR COUPLED TO A CENTRIFUGAL PUMP

On long lines the excess of the distributed leading charging current flowing back through the line inductance is sufficient to cause, at light load, a rise in voltage from generating to receiving ends. At heavy load, the lagging component in the load is usually sufficient to reverse the low load condition, so that a drop in voltage occurs from generating to receiving ends. The charging current of the line is, to a considerable extent, an advantage, for it partially neutralizes the lagging component in the load, thus raising the power factor of the system and reducing the capacity of synchronous condensers necessary for voltage control.

Voltage at the receiving end of the line should usually be held constant under all loads. To meet this condition, partially, the voltage of the generators can be varied to a small extent. On longer lines, however, the voltage range required of the generators would be too great to permit regulation in this manner. In such cases, phase modifiers

*From a paper read before the Transmission and Distribution Committee of the Ohio Electric Light Association.

†General Engineer, Westinghouse Electric & Manufacturing Co.

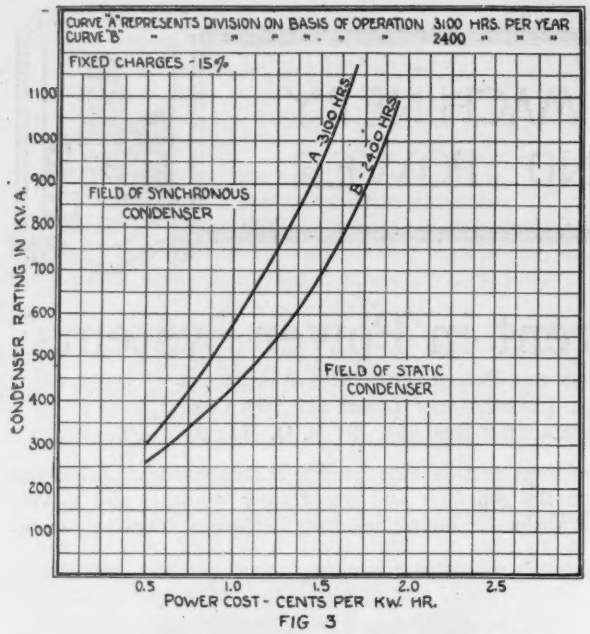


FIG. 3. CURVE OF COST COMPARISON, 2300 V.

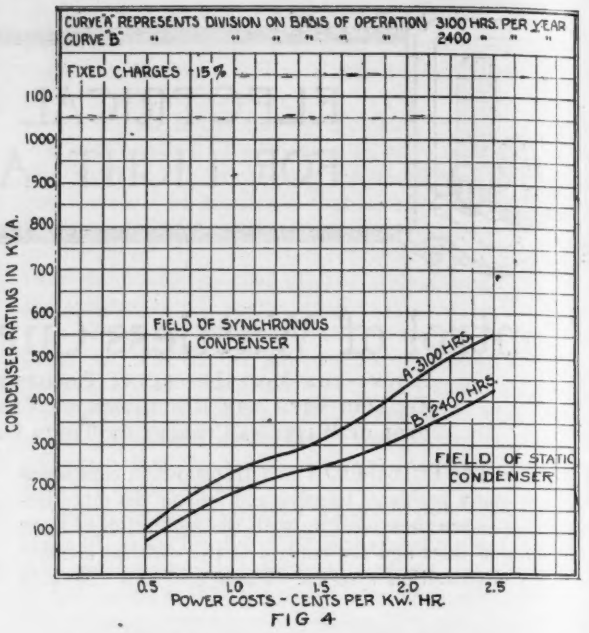


FIG. 4. CURVE OF COST COMPARISON FOR LOW VOLTAGES

operating in parallel with the load are employed. The function of these phase modifiers is to rotate the phase in the current at the receiving end of the line so that the self-induced voltage of the line, always displaced 90 deg. from the current, swings around in the direction which will result in the desired line drop. In some cases, a phase modifier is employed which has sufficient capacity not only to neutralize the lagging current at full load but, in addition, to draw sufficient leading current from the circuit to compensate entirely for the ohmic and reactance drop in the circuit. In this case, the voltage of the two ends of the line may be held the same for all loads. This is usually accomplished by employing an automatic voltage regulator on the exciter end of the phase modifier; but the voltage regulator may, if desired, be arranged to compound the substation bus voltage with increasing load.

Theoretically, for most efficient results the system power factor should approach unity but the cost of synchronous apparatus having sufficient leading current capacity to raise the power factor to unity increases so rapidly as unity approaches that it is uneconomical to carry the power factor correction too high. It usually works out that it does not pay to raise the power factor above 90 to 95 per cent except in cases where a synchronous condenser equipment is used for voltage control rather than for power factor improvement.

In any synchronous machine it can be readily demonstrated, that, if the current flowing through the armature coil is in phase with the voltage, it has comparatively little influence on the field flux. If the armature is carrying lagging current, this current will tend to magnetize the armature core in such a direction as to oppose the field flux. This in turn reduces the flux through the armature coils and causes a lowering of the voltage. In order to bring the voltage back to its normal value, it is necessary to increase the field flux by increasing the field current. Generators are now usually designed with sufficient field capacity to compensate for lagging loads of 80 per cent power factor. If the armature is carrying leading current this leading component will tend to magnetize the armature core in such a direction as to add to the field flux. The resulting flux threading the armature coil is thus increased, causing a rise in voltage. Modern alternators are of such design that when carrying rated lagging currents at zero power factor, they require approximately 200 to 250 per cent of their no load field current and when carrying rated leading current at zero power factor, they require approximately — 15 per cent to + 15 per cent of their no load field current.

Low power factors demand large generators, exciters, transformers, switching equipment and conductors. Loads of 70 per cent power factor demand equipment of 28 per cent greater capacity than would be required if the power factor were 90 per cent. The cost of apparatus for operation at 70 per cent power factor would be approximately 15 per cent greater than the cost of similar apparatus for 90 per cent power factor operation.

As is well known, leading armature current by increasing the field strength of a generator causes an increase in the voltage produced in the armature and consequently an increase in the terminal voltage of the machine. If an alternator with its fields open is switched on to a dead transmission line, having certain electrical characteristics, it will become self-exciting, provided there is sufficient residual magnetism present to start the phenomenon. In such a case the residual magnetism in the fields of the generator will cause a low voltage to be generated which will cause a leading line charging current to flow through the armature. This leading current will increase the field flux which in turn will increase the voltage, causing still more charging current to flow and thus building up the voltage until it is stopped by the saturation of the generator fields. This is the point of stable operation.

The term synchronous condenser is applied to a synchronous machine for raising the power factor of circuits. It is simply floated on the circuit with its fields over excited so as to introduce into the circuit a leading current. Such machines are usually not intended to carry a

mechanical load. When this double duty is required, they are referred to as synchronous motors for operation at leading power factor. On long transmission circuits where synchronous condensers are used in parallel with the load for varying the power factor, thereby controlling the transmission voltage, it is sometimes necessary to operate them with under excited fields at periods of light loads. They are then no longer synchronous condensers but, strictly speaking, become synchronous reactors.

Whether synchronous motors for operation at leading power factor, synchronous condensers or synchronous reactors be used, they virtually do the same thing, that is, their function is to change the power factor of the load by changing the phase angle between the armature current and the terminal voltage. These are, sometimes, therefore, referred to as phase modifiers.

Synchronous condensers, as regularly built, may be operated at from 30 per cent to 40 per cent of their rating lagging, dependent upon the individual design. Large lagging loads result in unstable operation on account of the weakened field. Phase modifiers can be designed to operate at full rating both leading and lagging but they are larger than the corresponding synchronous condenser and require larger exciters, have a greater loss and cost 15 to 20 per cent more than standard condensers. Normal design of a synchronous phase modifier usually contemplates a lagging rating of 50 per cent to 75 per cent of normal.

Synchronous condensers are generally built for high speed and equipped with shafts of small diameter. If they are to be used to transmit some mechanical power, it may be necessary to equip them with larger shafts and bearings, particularly if belted rather than direct connected. If a phase modifier is to furnish mechanical energy and at the same time to operate lagging at times of light load for the purpose of holding down the voltage on an unloaded transmission line, there may be danger of the machine falling out of step if heavy mechanical load occurs when the machine is operated with a weak field.

At rated full load leading power factor the total losses, including those of the exciter, will vary from approximately 12 per cent for the smallest capacity to approximately 4 per cent for the larger capacity 60 cycle condensers. The approximate values of the losses in standard 60 cycle synchronous condensers are as follows:

SYNCHRONOUS CONDENSER LOSSES

Lagging Kv.a.	Lagging Loss Kw.	Kv.a.	Loss Kw.
100	12	3500	180
200	18	5000	220
300	22	7500	320
500	32	10,000	420
750	47	15,000	620
1000	55	20,000	820
1500	70	25,000	1000
2000	120	35,000	1400
2500	130	50,000	2000

While the field excitation of various condensers naturally depends on their design, for a typical unit operating from full load lagging to full load leading, with no mechanical work being done, the range of excitation is from 2.3 to 1.

Ordinary alternators may be employed as synchronous condensers or synchronous motors by making proper changes in their field poles and windings to render them self-starting and safely insulated against voltages induced in the field when starting.

The nearer the center of load that the improvement in power factor is made, the better, as thereby the greatest gain in regulation, the greatest saving in conductors and apparatus are made, since distribution lines, transformers, transmission lines and generators will all be benefited.

For line regulation, synchronous phase modifiers are usually necessary, while for the control of the wattless element in a distribution circuit, it may be said that the field of application of synchronous condensers is the relatively large rating and that static condensers have a more favorable field in the smaller sizes.

While each case should be figured on its own merits, it is frequently found that it does not pay to install a synchronous condenser if increased efficiency is the only motive. The improvement in power factor can be more cheaply and efficiently obtained by the installation of one or more synchronous motors designed for operation at leading power factor. Sufficient capacity of these will give, in addition to mechanical load, sufficient leading current to raise the power factor to 90 per cent. The extra expense and increased loss of synchronous motors, enough larger to furnish the necessary leading component for power factor correction, is very small.

Figure 1 shows a 150-hp., 1200-r.p.m. bracket type synchronous motor with direct connected exciter. This is typical of a small high speed motor for use in place of an induction motor of equivalent rating. The synchronous motor can readily be operated over excited to improve the power factor of the load.

Figure 2 shows a 450-hp., 106-r.p.m. synchronous motor coupled to a centrifugal pump used in the Chicago Sanitary District.

STATIC CONDENSERS

During the last few years, there has been a great advancement in the design and manufacture of static condensers which have thoroughly justified their existence as workable and reliable devices. In any problem for the reduction of the wattless component, after the determination of the amount of corrective kv.a. required in a given case, the choice of the type of equipment should be made on the basis of economy. The economic merits of power factor corrective equipment can be considered as the total yearly cost per corrective kv.a. This cost should include the following items:

A fixed charge on the investment, including the price of the equipment and the cost of installation. This fixed charge should take care of interest on the investment as well as covering insurance, taxes and depreciation charge.

A charge for maintenance and attendance.

A charge to cover the cost of the energy consumed by the equipment.

It will be found that with a given number of hours use and a given percentage (somewhere between 10 per cent and 15 per cent for the fixed charge, the choice between the synchronous and static condensers depends upon two quantities: one, the amount of corrective kv.a. required, and the other the energy rate. Two sets of curves have been prepared which show the division of territory for the conditions assumed.

Figure 3 applies to installations where the condenser can be placed directly on the circuit without the use of transformers. With static condensers, it is at present practicable only on circuits where the voltage is 2300 and

higher. Later designs of condensers may be made permitting their use directly on some lower voltage. Curve A is drawn on a basis of 3100 hr. per year, namely 10 hr. per day, 310 days. While curve B on the 2400 hr. basis is on the idea of 8 hr. per day, 300 days. Each curve is drawn through a number of critical points above which the synchronous condenser shows the better economy and below which the static condenser appears preferable. Thus suppose that a customer is in need of 700 corrective kv.a. that he operates about 3100 hr. per year and his power cost averages one cent per kilowatt hour and that the condenser can be applied directly to a 2300 v. circuit. The co-ordinate 700 kv.a. at the one cent power rate, locates a point above the curve A. which indicates a synchronous condenser as the preferable type. With a power cost of 1½

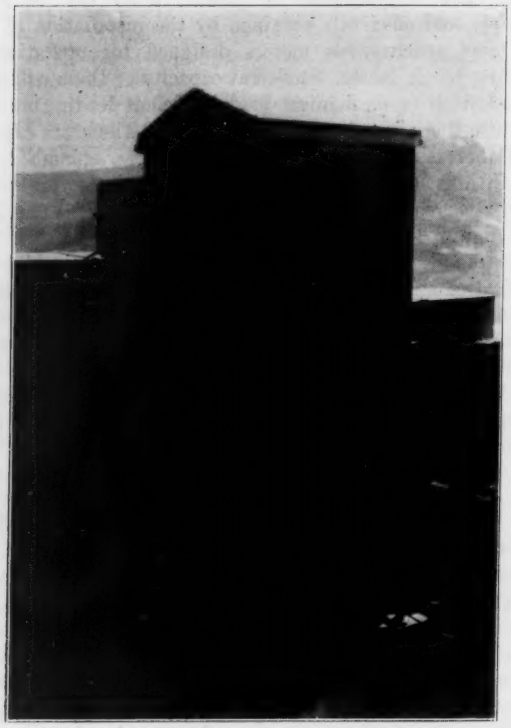


FIG. 5. OUTDOOR STATIC CONDENSER EQUIPMENT INSTALLED ON ROOF OF BUILDING

cent, the point would be located below curve A., indicating that a static condenser would be the better. Suppose, however, that the customer operates on 440 v. Then referring to Fig. 4, the synchronous condenser is preferable at either a one cent or a two cent power rate. Take as another case, a customer requiring 300 corrective kv.a., operating at 220 v., 2400 hr. per year with an average power rate of 2¼ cents per kw.-hr. This indicates that the static condenser is the type he should have. Suppose, however, his power rate is 1½ cents. With other conditions of operation the same as before, he should have a synchronous condenser.

While the curves are representative of an economic division that will exist between the two types under any practical conditions, each curve in itself is based upon certain definite premises and is strictly true only so long as those premises hold. Thus a change in price of either type of equipment will change the critical ratings which form the curves. Assumption of a definite fixed charge will have a similar effect.

Power consumption of a synchronous machine becomes a more formidable factor than the total yearly cost and, consequently, the range of advantage for the static type is extended to a higher critical rating, if a lower percentage or fixed charge is assumed.

In connection with installation costs, comparisons on the basis of weight are instructive. In the 300 kv.a. rating, the 2300 v. static and synchronous equipment weigh about the same, approximately about 10,000 lb. Below 300 kv.a. a 2300 v. static equipment weighs less than a synchronous equipment of the same rating. Above 300 kv.a. the static equipment becomes the heavier. At 500 kv.a. the ratio is about 1.4 to 1 and 1000 kv.a. about 1.8 to 1. The low voltage static equipment shows less favorably in this respect because of the addition of transformers. At and below 150 kv.a. the two equipments show no great difference in the weights and corresponding ratings but in higher capacities the difference becomes more appreciable, the static equipment being heavier than the synchronous in a ratio of about 1.6 to 1 in the 250 kv.a. rating and about 2.8 to 1 in the 500 kv.a. rating.

Consideration must be given to the fact that while the synchronous machine includes a rotating part and usually necessitates special provision in the way of foundation, the static equipment is entirely stationary and can be installed with no more expensive provisions than are requisite to support the inert weight of the apparatus.

The question of housing is of importance and the relative floor space requirements show that in the 100 kv.a. rating, the total floor space occupied by the static equipment is about 60 per cent of that occupied by the synchronous equipment. In the 200 kv.a. rating the two equipments differ little, the static taking the greater space in the ratio of 1.1 to 1. At 300 kv.a. this ratio increases to about 1.9. At 500 kv.a. it becomes three to one. At 1000 kv.a. it becomes 4.2 to 1.

While in the higher rating the synchronous equipment appears decidedly the more economical in space requirements, it should be considered that the synchronous machine actually requires somewhat more working space than that covered by the outline dimensions of the machine and switching equipment, while the static condenser requires very little more than that assigned on this basis. Moreover, the nature of the synchronous equipment is such that its location should be selected with more or less care, while the static condenser can be placed in almost any suitably protected location, convenient to the power circuit. Figure 5 shows an equipment of static condensers that has been operating for several years on the roof of the Westinghouse Works exposed to all the vagaries of the Pittsburgh climate.

While the maintenance on the synchronous equipment is low that on the static condenser is practically zero. The item of maintenance may or may not be a considerable factor in the case of the synchronous equipment, depending upon whether or not there is already available a man who can operate the equipment and give it the small amount of attention necessary. Attendance on the static equipment is practically negligible.

A point in favor of the synchronous equipment is the possibility of varying the amount of reactive kv.a. taken by the condensers within the rating of the equipment. In considering future development of a plant, the static type

has an advantage in the ease with which additional corrective capacity can be obtained by adding the desired number of units to an existing installation.

In dealing with a power factor correction problem, investigation should always be made of the possibility of applying to some drive a synchronous motor of such capacity as to furnish the horsepower output necessary for the drive and at the same time to operate at a leading power factor so as to furnish the corrective kv.a. needed. If such a motor can be properly applied it will usually be found that the cost chargeable to power factor correction is low.

In considering the relative use of static and synchronous condensers, there are certain broad tendencies which give an idea of the general fields of application. Static condenser equipments are made up of units and, therefore, the cost per kv.a. is nearly the same for all sizes. Synchronous condensers, on the other hand, cost far less per kv.a. in the larger sizes than in the small sizes. The unit construction of static condenser equipment affords easy handling without special equipment and with few men. The foundation required is less expensive than for the synchronous condensers since the only requirement is to support its weight. In general, from the standpoint of first cost, the static condensers show up best in the small sizes and the synchronous condensers in the large sizes.

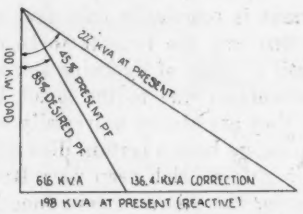


FIG. 6. TYPICAL EXAMPLE OF POWER FACTOR CORRECTION

The power loss in a static condenser is approximately 5/10 of 1 per cent except where transformers are required, when the transformer losses varying from 3 per cent in the small sizes to 2 per cent in the large sizes must be added. The losses in a synchronous condenser vary from 10 per cent in the small sizes to 3½ per cent in the large sizes. For the application under consideration, the cost of power losses should be figured at the prevailing energy rate at the normal hours of operation to give the total yearly cost.

While the attendance required for static condensers is somewhat less than for synchronous condensers, it may be assumed, with at most a small error, that a yearly charge of 15 per cent represents a normal carrying charge for either equipment.

Due to its simplicity the field of the static condenser, particularly in the more moderate sizes, is rapidly extending. The static condenser is a piece of apparatus designed primarily to improve the power factor of inductive loads, or it may be stated that the static condenser is a device for storing electro-static energy in the form of an electro-static field. A static field is opposite in characteristics to a magnetic field as required by inductive apparatus, in that it takes a current which leads the voltage instead of lagging behind the voltage. When proper proportions of magnetic fields and static fields are operated in parallel, there follows a continual transfer of magnetic and electro-static energy from one to the other. The wattless current is confined to the portions between the condenser and the load. The power factor of the combination then becomes unity or near unity, depending on the size of the condenser relative to the load.

The kv.a. of static condensers required to correct any given power factor to any desired power factor is entirely dependent on the kw. load in the plant, inasmuch as a condenser which would correct the 100 kw. load from 50 per cent power factor to unity power factor, would only increase the power factor to 76 per cent if the kw. load was 200. Figure 6 shows a typical example of power factor correction.

Taking the case of an industrial plant whose average load is 100 kw., the average power factor is 45 per cent. The power rates are assumed to be such that a penalty is imposed for power factors below 85 per cent and the penalty is such as to warrant the installation of power factor correcting apparatus. That is, the annual saving, by correcting the power factor, will more than offset the interest, upkeep and depreciation of such equipment. In some cases, it may prove profitable to correct the power factor up to unity; but for the present case, all that is desired is to correct the power factor to 85 per cent. At 45 per cent power factor the rated kv.a. is 222 and accordingly the power transformers must be sufficiently large to take care of it. The reactive or wattless kv.a. is the vector difference between 222 and 100 kv.a. or 198 kv.a. At 85 per cent power factor the total kv.a. will be 117.8 which shows that the customer's transformers capacity can be cut practically in half. The wattless kv.a., in this case, will be 61.6 so that the necessary corrective effort to change the load from 45 to 85 per cent power factor will be 198-61.6 or 136.4 kv.a. The static condenser would be a 136 kv.a. outfit, mounted in frames of 150 kv.a. capacity.

Current Limiting Reactors and Choke Coils

THESE DEVICES ARE EXTREMELY VALUABLE IN PROTECTING ELECTRIC EQUIPMENT FROM DAMAGE DUE TO SHORT CIRCUITS AND OTHER UNUSUAL CONDITIONS. BY FRED C. DEWEESE

CURRENT-LIMITING reactors are designed for the protection of generators, transformers, feeders and other electrical apparatus against short circuits.

If the power system is small, with a limited amount of generating capacity back of it, current-limiting reactors are not of so much importance, due to the fact, that, when a short circuit occurs on the system, the voltage will usually drop to such an extent that there is little or no damage done to the apparatus. If, however, the system is large, with practically an unlimited amount of generating capacity, if there is no way of choking back the enormous amount of current that will flow at the instant of the short, due to the practically full sustained voltages, serious damage may be the result.

Reactors are generally considered as introducing a certain percentage of reactance in the circuit. The percentage of reactance is the ratio of the voltage drop across the terminals of the reactor to the voltage between line and neutral on a three-phase circuit, or the voltage between the lines of a single-phase circuit, when the rated current of the circuit at rated frequency is flowing through the reactor. The reactance should always be expressed as

the percentage of reactance to neutral, or as single-phase reactance.

The kv.a. rating of a reactor is the product of the voltage drop across the reactor and the rated current. For example: If the voltage drop across the terminals of the reactor is 150 v. and the current flowing through the reactor is 300 amp., the kv.a. of the reactor is $150 \times 300 = 45$ kv.a.

Reactors as a rule do not have iron cores; therefore, the reactive drop is proportional to the current flowing. As far as all practical purposes are concerned, the drop due to the ohmic resistance may be neglected. If a circuit having a 4 per cent reactor were to be short-circuited at the reactor terminals, with full sustained voltage, the current would be limited to $100 \div 4 = 25$ times normal rated current.

When designing an installation of current limiting reactors for the purpose of protecting electrical apparatus, care should be exercised to determine the reactances of the transformers, generators, etc., and these various reactances should be added to the reactance of the reactors. If this is not done, the percentage reactance of the reactors may be figured too high, with a consequent excessive voltage drop during times of normal operation.

It is essential that the per cent reactances of a system are on the same basis, that is, on the same current value. If the per cent reactance of a 1000-kv.a., three-phase transformer is given as 6 per cent but a value is required which corresponds to that of a 2000-kv.a., three-phase generator, the corresponding value will be $1000/2000 \times 6 = 3$ per cent. It should also be remembered that reactance values given for a single-phase transformer really refer to a bank of three single-phase transformers.

A reactor designed for a given frequency may be used in a circuit of a different frequency, in which case the per cent reactance is approximately equal to the ratio of the frequency for which it is to be used to the frequency for which it was designed times the per cent reactance for which it was designed.

For example: A 3-per cent reactor designed for 25 cycles may be used on a 60-cycle circuit, in which case the per cent reactance is approximately equal to $60/25 \times 3 = 7.2$ per cent.

A 3-per cent 13,200-v. reactor may be used on a 6600-v. circuit, in which case its per cent reactance will be $13{,}200/6600 \times 3 = 6$ per cent. Or in other words, the per cent reactance of a reactor is inversely proportional to the ratio of the voltages.

A reactor may be used for a lower current than that for which it was designed, in which case its reactance is directly proportional to the current's. For example: A 3-per cent reactor designed for 300 amp. may be used for a current of 200 amp., in which case its reactance will be equal to $200/300 \times 3 = 2$ per cent.

From the foregoing it may be seen that a 3-per cent, 25-cycle, 13,200-v., 300-amp. reactor will operate in a 60-cycle, 6600-v., 200-amp. circuit as follows:

$60/25 \times 13{,}200/6600 \times 200/300 \times 3 = 9.6$ per cent.

Choke Coils

Choke coils are designed for the purpose of protecting transformers, generators, switches and other electrical apparatus from high voltage, high frequency surges, which are in general caused from lightning disturbances.

When a lightning disturbance or any high voltage charge travels along a line, it usually has an exceedingly steep wave front. The incoming wave striking the windings of a transformer, generator or other apparatus piles up, so to speak, and frequently breaks down the insulation of a few of the end turns. This shorts out the turns that have the insulation destroyed. If the apparatus happens to be a transformer, this breaking down of the insulation changes the turn ratio of the high voltage winding to that of the low voltage winding, thus causing an increased voltage to be induced in the low voltage winding and in many cases this secondary voltage reaches a dangerous point.

If we have a choke coil connected in the circuit between the transformer and the line, and a lightning arrester connected to the line ahead of the choke coil, when the steep wave of high frequency voltage comes, the choking back of the surge will cause a higher than normal voltage across the spark gap of the lightning arrester and it will discharge to ground. When the energy from this surge is dissipated, the arc will break and the system will immediately return to normal.

The use of choke coils is based on the preceding phenomenon and it is to choke back the crest of the wave that they are used.

Choke coils should be, and are, designed so that in times of normal operation, the impedance of the coil to the flow of current is practically only that of the ohmic resistance. In this way the benefits to be derived from the use of the coil at times of lightning storms so far outweigh the disadvantages due to the small IR drop and I^2R losses, that they are almost universally used.

Lightning arresters have a certain dielectric spark lag; that is, after a high potential steep wave front, lightning discharge comes in, there is a certain time lag, or small interval of time before the arrester begins to discharge to ground. If there is a choke coil between the lightning arrester and the apparatus to be protected, the turns of the choke coil will receive this high voltage strain, choke it back and protect the apparatus during the time interval in which it takes the arrester to get into operation.

Choke coils should in practically all cases be recommended for the protection of all classes of electrical apparatus, unless it be a cable line. If a choke coil is connected in series with a cable line, this is equivalent to connecting an inductance and a capacity in series, and under certain conditions due to resonance, may cause a high voltage to be built up at the terminals of both the choke coil and the cable. This is the very thing which the choke coil was designed to prevent.

A new type of safety device, designed for use by persons caught in mine or other atmospheres containing carbon monoxide, has been approved by the Bureau of Mines under the schedule for establishing a list of permissible gas masks. This new device, called the "self rescuer," is a pocket-size canister filled with granular fused calcium chloride and "hoolamite" (a mixture of specially prepared copper oxide and manganese dioxide) which removes any carbon monoxide from the air inhaled. The purpose of the self-rescuer is to enable a miner to escape when caught in carbon monoxide after a fire or explosion, and to save the lives of workers at blast furnaces or other plants where carbon monoxide may be encountered. It is not intended to replace for use in rescue work either breathing apparatus or carbon monoxide gas masks with large canisters.

New Boiler Plant for Chester Gas Works

Stoker Fired Boiler Plant Shows Great Improvement Over Hand Fired Plant It Replaces

AN UNUSUALLY fine example of small boiler plant construction is had in a new boiler house recently erected at Chester, Pa., by the Philadelphia Suburban Gas and Electric Co. This plant, which replaces an old boiler plant, was built to supply steam for operating gas compressors and gas generators in the manufacture of illuminating gas. The water gas generators are large consumers of steam and when all of them were in operation the steam pressure dropped to such a point that the old boiler plant was unable to carry the load.

bottom with a coal valve which allows the coal to fall by gravity into the receiving hopper of a traveling weigh larry. The latter is electrically operated and travels the entire length of the boiler room. All coal and ash handling equipment with the exception of the ash hoppers and ash gates are of C. W. Hunt manufacture. The larry is operated directly from the car itself by means of a drum controller. It weighs and records each charge of coal before delivering it to the stoker hoppers. It operates on 3-phase, 220-v. current supplied by the transformers in the basement.

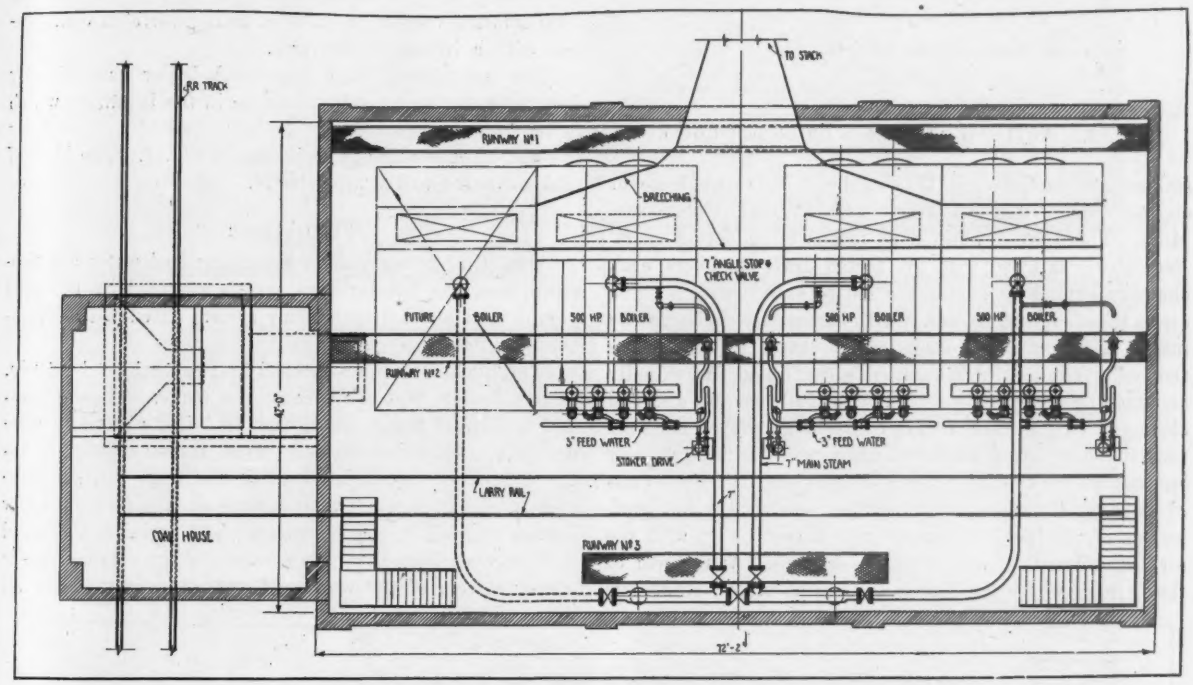


FIG. 1. PLAN OF BOILER ROOM, SHOWING MAIN STEAM PIPING

Hand firing was used in the old plant and although the boilers were operated with forced draft, the steam pressure fluctuated widely. Normal steam pressure carried was 125 lb. but with the water gas generators in operation this often dropped to 75 lb. With the new plant, steam pressure conditions are greatly improved and the overall efficiency of the plant is much higher.

The New Plant

The new boiler house, as may be seen from the photograph, is a two-story brick and steel structure with the coal and ash handling equipment at one end of the building. The basement is on a level with the grade; due to the proximity of the plant to tide water, it was not feasible to go down below grade on account of the excessive cost of waterproofing which would have been necessary. The concrete stack shown in the picture is 200 ft. high and was built by the General Concrete Construction Co.

Coal is delivered into an overhead bunker at one end of the boiler room by means of an electrically operated skip hoist. This bunker is of concrete and is fitted at the

At the present time three 500-hp. Edge Moor boilers are installed. These are set in one row in groups of two (provision having been made for the installation of a fourth unit at some future date) as shown on the plan view of the boiler room floor, Fig. 1. Under present conditions the load will be carried by two boilers operating at 200 per cent rated capacity. This method of operating leaves one unit in reserve at all times—an extremely desirable condition.

These boilers are normally operated at about 125 lb. pressure. No superheat is used, as the nature of the service is such that it would not be materially improved by the use of superheat. The construction of the boilers is shown in Fig. 5. They are of the longitudinal type fitted with inclined baffles. The lower row of tubes is located about 12 ft. above the level of the grates. The furnaces are fitted with double suspended Liptak arches, and the side walls have three courses of carborundum brick at the level of the stokers.

All boilers are equipped with Harrington stokers built by the United Machine Works of Canton, Ohio. These

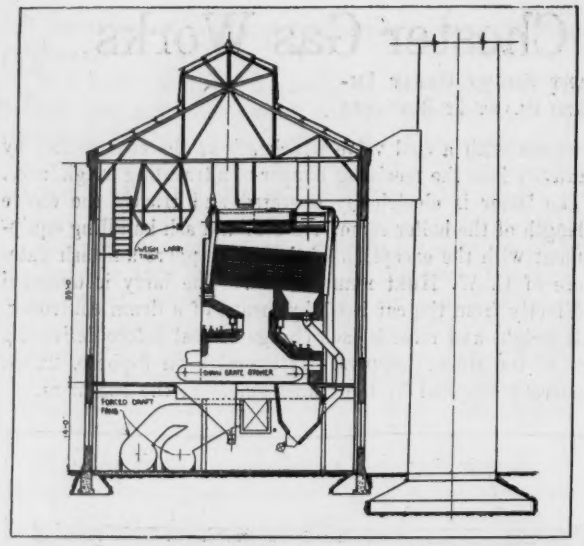


FIG. 2. SECTIONAL ELEVATION OF BOILER HOUSE

stokers are each driven by a 4 by 4-in. vertical steam engine made by the Clarage Fan Co., of Kalamazoo, Mich. The drive is effected by means of reduction gears. Each stoker is fitted with five forced draft chambers, each chamber extending across the entire stoker width. The air to these zones or forced draft chambers is controlled by means of a damper, in each zone, operated by hand from the boiler front. Each damper is controlled individually and may be set at any point between full opening and full closing. This method of air control has proved satisfactory in chain grate stoker practice and has been largely responsible for the application of forced draft to this class of stokers. By means of this system, the air through each section of the fuel bed is regulated in accordance with the air requirements of the respective sections. At the rear of the furnace where the fuel bed is comparatively thin, it is obvious that not as much air is necessary as towards the front where the fuel bed is thick. By means of the dampers, the air supply can be controlled to a nicety. With the damper lever in the closed position, no forced draft enters the chamber. When open, the output of the forced draft fans is in direct communication with the air chamber, and a maximum amount of air passes through the fuel bed. The type of stoker used in this plant was selected largely because of its ability successfully to burn coke breeze which is the fuel used. Combustion is automatically controlled by the Grey system.

Accessory equipment on the boilers includes four Consolidated safety valves on each unit, 7-in. Foster nonreturn valves, Diamond soot blowers, five units per boiler, Reliance water columns, S—C feed water regulators and Everlasting straight-through blowoff valves. The blowoff arrangements consist of an Everlasting valve in combination with a Nelson angle valve.

The two blowoff lines from each boiler pass directly downward, to the main blowoff line in the basement which in turn discharges into the underground blowoff tank at one end of the buildings as shown in Fig. 4. The blowoff tank is vented to the atmosphere.

Feed Water

Two separate methods of supplying feed water are provided, one, the regular feed system supplied by the feed pumps, and another emergency system fitted with Metropolitan injectors.

The main feed line is served by two 10 by 6 by 10-in. duplex feed pumps of Worthington make. These pumps had previously been used in the old boiler plant and were moved to the new plant for service there. These pumps are located in the basement, as shown in Fig. 4, and take suction directly from two Cochrane open type feed water heaters located in the old plant. The water is delivered to these open heaters by the pressure of the common water supply system of the works. River water is used for all

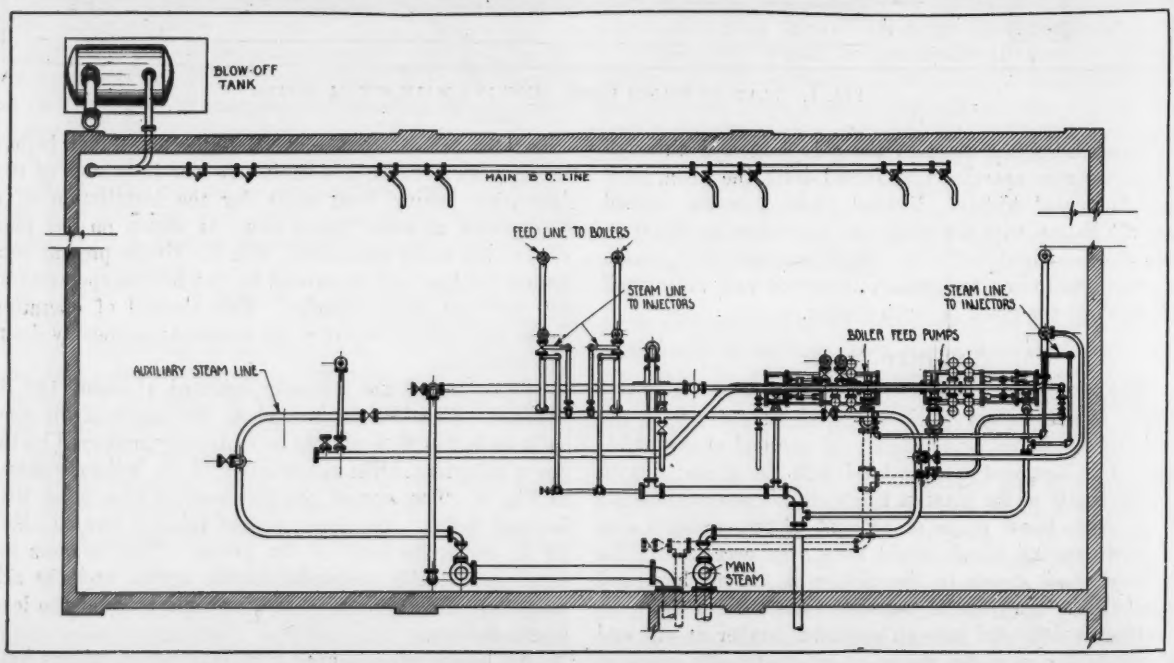


FIG. 4. BASEMENT PIPING, SHOWING LOCATION AND ARRANGEMENT OF FEED PUMPS

purposes including boiler feed. This water, although it contains a considerable amount of suspended matter, is fairly good water. It is drawn from the river into a settling basin by gravity, and after the solid matter has settled, is pumped throughout the works by two duplex pumps working under about 45 lb. pressure. Water used for boiler feed purposes is treated with a compound which the operators claim has given good satisfaction.

FIG. 3. VIEWS OF THE NEW BOILER PLANT OF THE PHILADELPHIA SUBURBAN GAS AND ELECTRIC CO.

A An exterior view showing the coal and ash handling arrangement and the 200 ft. stack.
B Three boilers are installed at the present time although provision has been made for the future installation of a fourth unit.
C A view in the basement showing the ash hoppers, forced draft duct and sifting hopper.
D One of the two forced draft fans installed is driven by a synchronous motor while the other is turbine driven.

Forced Draft

Forced draft for the furnaces is supplied by either of two Sirocco fans built by the American Blower Co., of Detroit. Each fan is capable of supplying 39,000 cu. ft. of air per minute against a static pressure of 4½ in.

These fans are arranged as shown in Figs. 2 and 3D. One is driven direct by a 50-hp., 1200-r.p.m. Terry turbine, while the other, as may be noted in the photograph, is direct connected to a 48-hp. synchronous motor. The latter, together with the starting equipment, was furnished by the Electric Machinery Mfg. Co., of Minneapolis, Minn.

This type of motor was installed in order that the effect of the leading current taken by the machine might be utilized in raising the power factor of the system, which was somewhat low.

Ashes accumulate in steel ash hoppers below the boilers from which they fall by gravity into the ash cars running on rails immediately below. The ash pits together with the balanced ash gates were furnished by the Beaumont Mfg. Co. Sifting hoppers are also provided, as may be seen in Fig. 2 and 3C. Siftings which drop through the chain grate stokers collect in these hoppers and when a sufficient amount has accumulated, they are removed and redelivered to the stokers.

The ash cars deliver their loads to the skip hoist at one end of the building, which delivers the ash into the concrete ash storage bin above.

XUM

Transformer Vault

A small transformer vault is located in the basement. This contains two, 25-kv.a. single-phase Packard transformers, 2200/220 v. serving the coal handling equipment, and one 10-kv.a. unit 2200/110 v., for lighting service. The skip hoist is controlled by a Cutler-Hammer automatic contactor panel located near the transformer vault. The synchronous motor driving the forced draft blower previously mentioned, is connected directly to the 2200-v. line. All current is delivered to the plant at the latter voltage.

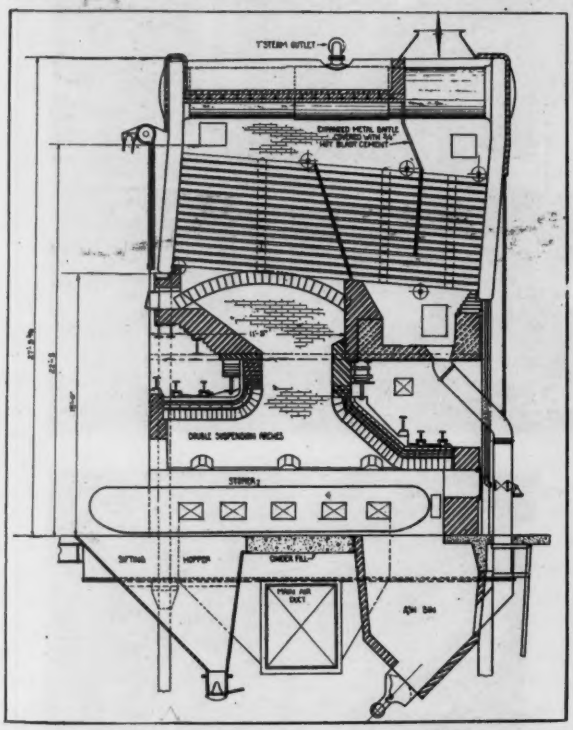


FIG. 5. SECTION THROUGH ONE OF THE 500-HP. BOILERS

Conclusion

In concluding this description we wish to comment upon the exceptionally clean, and neat appearance of the plant, a point which is well brought out in the accompanying photographs. In designing the plant, simplicity seems to have been a governing factor, and everything has been installed with the view of obtaining reliability of service, although in no case has efficiency been sacrificed to accomplish this. A well-selected group of instruments has been installed for indicating and recording temperatures, pressures and rates of flow, and operation is carefully checked. The boiler room is light and airy, and all equipment is easily accessible. Valves and fitting on top of the boilers and in the upper part of the boiler room, may be operated from a system of runways and suspended gratings. All steam piping is covered with ample thicknesses of 85 per cent magnesia insulation, and the boiler settings are kept tight against air leakage by suitable coatings of insulating paint.

The plant was designed and constructed by the Philadelphia Suburban Gas & Electric Co. We wish to acknowledge our indebtedness to R. G. Porter, Superintendent of Manufacture of the Philadelphia Suburban Gas & Electric Co., for information and courtesies extended in gathering material for the preparation of this article.

Flow Meters Increase Boiler Efficiency

By Philip Werner*

OVER a year ago we installed flow meters in our boiler house and the information given us by the meters has been of great aid in the operation and supervision of our steam plant. Steam is generated with one 200-hp. and two

THESE INSTRUMENTS HAVE POINTED THE WAY TO BOILER ROOM SAVINGS OF OVER FIVE PER CENT

150-hp. fire-tube boilers burning oil. The load carried by each boiler is shown by the flow meter connected to it. For each boiler there is an indicating, a recording and an integrating instrument. The current for the meters is supplied by a small rotary converter. The meter for No. 1 boiler is rated for a maximum of 265 hp. and the other two are both rated for 225 hp. The meters are located in a prominent place in front of the boilers.

On the three boilers, the total load averages between 500 and 600 hp. during the day and drops off to about 400 hp. during part of the night. The load fluctuates more or less at all times except late at night. Our three flow meters indicate fluctuation in the total load and changes in the distribution of the load between the boilers due to uneven draft or fire conditions. As the load fluctuations are indicated as soon as they occur, proper adjustments to meet them can be made promptly. This eliminates sudden forcing and makes it possible to operate the boilers with a minimum variation in firing, which reduces the wear on the settings and helps to avoid tube failures.

With the flow meters, each boiler can be operated at a rate near the point of highest efficiency, which is about 140 per cent of rating for these boilers. The meters indi-

*Chief Engineer, John F. Trommer, Inc., Brooklyn, N. Y.

cate when the total load has fallen to such a point that one or more boilers should be cut out in order to secure the most economical results.

Accurate Data on Boiler Operation

Daily records are kept of the amount of fuel oil consumed and of the amount of water evaporated as shown by the integrating flow meters. From these records we calculate the evaporation obtained per pound of fuel oil. This figure gives us a check on the operation of the plant every day in the year.

Before the flow meters were put in it was impossible to have any accurate knowledge of the performance of our boilers. We were operating in the dark as far as the total load being carried and the distribution of load between boilers was concerned. When we try to operate the boilers without looking at the meters now, we realize how necessary they are.

Increase Efficiency and Reduce Repairs

Previous to installing the meters a comparatively large amount of forcing of the boilers was required in order to recover and hold the pressure. This has been largely eliminated now that the fireman knows exactly what the load is at every moment and just how each boiler is operating. The fireman also knows that the charts will show any error on his part and he naturally is more careful than formerly.

These improvements in the operation of the plant have materially increased the efficiency. As we could maintain no running records before the installation of the meters, we do not know what the average conditions were at that time. Tests which were made before we had the meters, however, indicate that the operating efficiency was 5.6 per cent lower than it is at present. Increasing the efficiency 5.6 per cent would save about 41,140 gal. of fuel per year worth $1,851.30. The even firing of the boilers and elimination of most of the heavy forcing have greatly reduced the maintenance costs of grates, lining, etc., thereby effecting a saving in repairs estimated at $825 a year.

The total operating cost per meter amounts to about $42.18 per year or $0.12 a day. Deducting this cost from the savings effected leaves a net saving of $2,549.76 per year. According to this estimate, the entire cost of the three meters is repaid in less than 5 mo.

Furthermore, it is possible that, as we continue to operate with the meters, we will obtain information regarding the use of steam in the plant, that will permit us to effect even larger economies.

Roof Construction for the Power Plant

Indifference in the Selection of Roof Types and Materials Often Results in Large Expense Charges for Maintenance

AS A GENERAL rule, no part of a building will cause more trouble to maintain than a roof which has been improperly chosen or poorly constructed. The design of a power plant involves more than the selection and arrangements of power units; it demands that a suitable housing be provided for those units.

In general, there are two types of roofs—the so-termed flat roof in which there may be either no pitch or a slight pitch to direct the water to the down spout openings and the A frame type or that in which there is a pitch of approximately 4 in. to the foot. The flat, or nearly flat type of roof is the simplest construction. The former is often preferred in factory buildings because it leaves a flat ceiling, at least cost, on the top story. To get the same effect with a roof in which there is a pitch, it is necessary either to lay the roof flat and construct a cinder fill with concrete surface drainage slope or to lay the roof with a slope and construct a false ceiling.

Structural material for any type of roof may be wood or steel or a combination of the two. Wood construction, however, is not in great favor around power plants due to the increased hazard of destruction by fire.

Roof trusses of the A frame type are often used for spans up to 80 ft. and where buildings are set singly, because deep valleys would be formed by placing two such roofs side by side. This type of roof provides excellent natural ventilation such as is required in boiler rooms. The steep sides of the roof facilitate the passage of warm air and gas to the ridge which may be provided with ventilators or a monitor. The careful design of a roof of this type will allow little resistance to the natural flow upward of the gas and warm air.

Ample space must be provided in the design of a roof for a boiler room for the withdrawal and replacement of boiler tubes (bent tube type) and still not waste a large space overhead.

Monitors Aid Ventilation

Flat roof trusses require additional height of the building at the eaves. The height of this type of truss is approximately one-eighth the span; therefore a truss which would span a distance of 65 ft. would be about 8 ft. high. This will add to the height and therefore the cost of the building. Both flat and pitched roofs are often provided with monitors which extend the full length of the building, the sides of the monitor being provided with ventilated sash. Since glass is a good conductor of heat, it stands to reason that under some conditions of the air, water will condense on the glass and drip on the machinery below unless a condensation trough is provided to catch the water. Ventilation may also be obtained by the use of metal ventilators which may be either round or square and which are provided with dampers.

Of equal importance in the selection of the roof type is a careful consideration of the kind of materials which will go into the roof covering. Two materials must be considered—those which are to be exposed to the elements and which must shed the water, and those which span the distance between roof trusses and purlins and which support the outside covering.

Wood is the most common substance used to bridge between the purlins. It is comparatively inexpensive although it is subject to combustion and decay. Wood is a poor conductor of heat and so will eliminate the troubles due to condensation and dripping. Some chemical treatments used to preserve the life of wood are inexpensive and so may be used where it is warranted. Concrete is often used for roof construction of the flat type. It is generally reinforced and poured in slabs about 4 in. thick, suitable

expansion joints of course being provided. A number of various systems of construction are used, among which are the typical concrete beam, girder and flat slab or merely the flat slab supported by structural steel numbers.

Solid concrete slabs are fairly good conductors of heat and therefore unless the room under the roof is well ventilated, moisture will condense on the under side. To

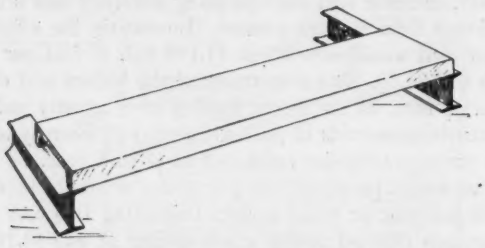


FIG. 1. SKETCH SHOWING A CONCRETE CHANNEL TILE IN POSITION ON PURLINS

overcome this some form of heat insulation must be provided. This insulation may be of the form of a cellular substance or hollow tile and it is laid directly on top of the slab and then the roof covering applied over the insulation material.

Pre-cast Concrete Tile

Another form in which concrete may be used in roof construction is the pre-cast concrete tile. For the flat type of roof where an outside covering is to be applied, the tile are laid with flush joints. They come in several styles such as: the plain reinforced flat tile, which is suitable for spans up to about 5 ft.; the channel tile which is made for

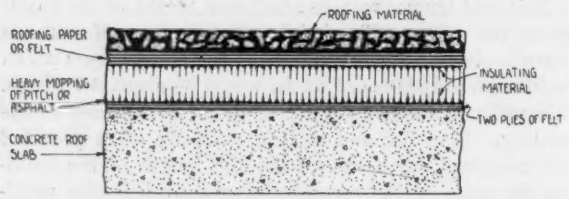


FIG. 2. SKETCH SHOWING LOCATION OF ROOF INSULATING MATERIAL

spans up to 10 ft. and the hollow tile which comes in lengths up to 10 ft. The two first mentioned types will require insulation in places where the air is humid. The safe, uniform load on these tile will be from 60 to 70 lb. per sq. ft. and they will weigh from 20 to 30 lb. per sq. ft., depending upon their construction.

Another form of concrete tile known as the interlocking tile is used on pitched roofs. These tile overlap and are cemented at the joints and therefore require no outside protective covering. They are generally colored red and present a pleasing appearance. These tile are light in weight as compared to the solid concrete slab type of roof.

Roofing May Be Made of Gypsum

Gypsum is a material which has of late years come into general use for roofing purposes. The points in its favor are that it is comparatively light in weight, it is non-combustible, it is a poor conductor of heat, it is permanent and can be easily handled. This material, as used for roofs, weighs about 77 lb. per cu. ft. and its insulating qualities are such that troubles from condensation are practically negligible.

This material can be mixed and poured on the job, or it may be obtained in several forms of pre-cast tile which are delivered ready to be placed on the purlins. The short span tile comes in 12 in. widths and 30 in. lengths. Those that are solid are 3 in. thick, and the hollow type are 3½ in. thick. The long span channel section type come 5 and 6 in. thick, 18 in. wide and from 4 to 8 ft. in length. Long span, 4 to 8 ft., hollow tile, can also be obtained.

Drainage Fills Made of Gypsum

Mixtures of gypsum and wood fibre, for saddles or drainage fill on roofs, are ideal, on account of the light weight and quick setting qualities. These mixtures are 60 per cent lighter than cinder concrete, set in 3 hr. and provide a smooth surface for the roof covering. It is an

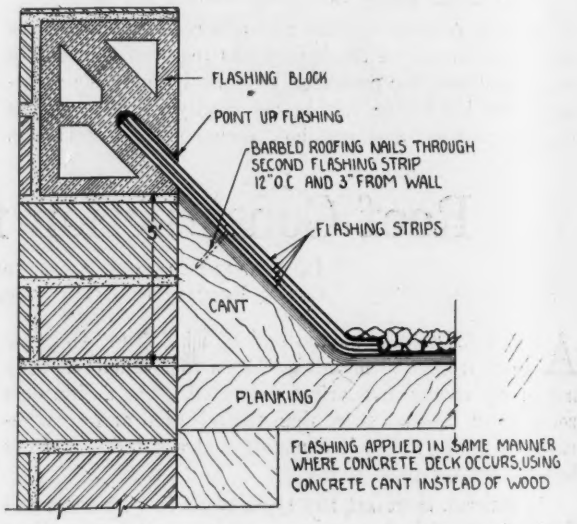

FLASHING BLOCK
POINT UP FLASHING
BARBED ROOFING NAILS THROUGH SECOND FLASHING STRIP 12" O.C. AND 3" FROM WALL
FLASHING STRIPS
CANT
PLANKING
FLASHING APPLIED IN SAME MANNER WHERE CONCRETE DECK OCCURS, USING CONCRETE CANT INSTEAD OF WOOD

FIG. 3. SKETCH SHOWING USE OF FLASHING BLOCK AND CANT

excellent means of constructing fillets and leveling off uneven and broken surfaces, in connection with difficult roof framing.

Roof tile, other than the interlocking type, should always be covered with a built-up asphalt or tar and gravel roof covering. On long span channel section and hollow tile construction, spot-mopping has been used with great success. This method leaves about 4 in. at the end of each tile unmopped and allows the waterproof covering a slight movement which is desirable at the end joints, thereby allowing for contraction and expansion which takes place in the supporting steel and is transmitted through the tile to the covering. Flat headed nails should be used when nailing into gypsum roof tile. The nails should have not less than 1½ in. penetration into the tile.

The normally white underside of gypsum can be successfully decorated or given a washable surface by the application of a recognized standard brand of paint, applied according to the manufacturer's specifications. A good lead and oil paint, or one with a lithopone base will give satisfactory results. The use of the latter is preferable where a pure white appearance is desired. It is essential that the tile be absolutely dry before applying the paint.

Strength and flexure tests conducted on gypsum will allow the following working stresses:

Compression in gypsum....	350 lb. per sq. in.
Shear in gypsum.....	20 lb. per sq. in.
Bond between gypsum and steel	30 lb. per sq. in.
Bearing of gypsum on looped reinforcement, anchor plates or cross welded wires	300 lb. per sq. in.
Modulus of elasticity of gypsum	1,000,000 lb. per sq. in.

Some roof coverings do not require an outside weatherproof covering. Such coverings are corrugated galvanized iron and corrugated zinc sheets. The iron requires frequent painting and is not considered as a permanent roof. The zinc sheet is permanent but, like iron, is a good heat conductor and is therefore subject to the troubles resulting from sweating. Corrugated iron can also be obtained with both surfaces and the edges covered with one or more layers of asbestos paper cemented to the metal.

Protective surface material is required on roofs constructed of wood, concrete and gypsum. Materials which will shed water are all that are required for high pitched roofs, while on low pitched or flat roofs the surface material must be waterproof so that water standing on it will not penetrate.

Pitch and asphalt are the two waterproofing materials best adapted to the flat or low-pitched type of roof. They are applied hot with layers of paper or felt between each of three to five coats. The paper or felt is laid with wide laps so that the completed roof is effective in resisting water pressure. Pitch melts at a lower temperature than does asphalt, therefore it is common practice to apply gravel over the top coating of pitch. This prevents the pitch from flowing towards the gutters or valleys during hot weather. Asphalt does not need this protection although it is frequently applied.

Prepared roofings are made up of these same materials. They come in rolls and are laid with a cemented lap of about 3 in. Dependence is therefore placed upon a single joint which makes this type of roof covering suitable for sloping surfaces where water does not stand and so exert a pressure on the joints.

Leaky roofs need not be tolerated, for a good roof will result from the use of good materials, properly laid. Of great importance for a satisfactory roof is the placing of flashing at all interruptions in the plane of the roof. This flashing should be of a permanent material and non-corrosive, and it should be set in a flexible manner so that it will not be broken due to expansion and contraction of the other roof materials. The flashing should always be carried to the highest point to which water can collect on the roof; that is, it should be carried as high as the crown of a flat roof, or to the level of some overflow such as weep holes extending through the parapet walls.

Drainage of a roof is always important and should be given careful consideration. Each leader connection should be water tight at its connection to the roof and it should be provided with a substantial screen over the opening so that trash cannot stop up the drain pipes. Drainage pipes or down spouts are subject to freezing in winter, therefore in cold climates it is preferable to run the down-spouts inside the building. Cast-iron soil pipe makes a good permanent installation for this service. On long runs of down-spouts, where the room temperature may vary over a considerable range, it is advisable to install a slip expansion joint in each down-spout at or near where they extend through the roof.

Steps in Overhauling an Ammonia Compressor

DETAILED DISCUSSION OF PROPER PROCEDURE IN DISMANTLING, TESTING ALINEMENT AND REASSEMBLING PARTS OF COMPRESSOR. BY J. F. STALEY

IN SHUTTING down an ammonia compressor for overhauling, one of the first things that should be done, although it is often overlooked as being too minor an item to deserve attention, is to test the suction and discharge valves connecting ammonia lines with compressor. How often we find men working on an ammonia compressor using electric fans or air from an air compressor to blow away the ammonia fumes. The time to repair these valves is before the ammonia compressor is dismantled, so that the lines can be properly pumped out.

If there is any doubt of these valves holding, allow the compressor to stand for 12 to 24 hr. after pumping out the cylinder. If at that time the ammonia compressor is found to have ammonia pressure on it, no doubt the valves are leaking. If it is the main discharge valve, the gage will show the same pressure as the gage on the ammonia condensers. If it happens to be the suction valve, it will show only the amount of pressure on expansion coils. Or it may be on the pump-out line. This, of course, can either have the condenser pressure on it or it may have only suction pressure on it, as a pump-out line should be connected to all parts of the plant so that in case of accident any part can be pumped out without interfering with another part.

If no leaks are found in these valves, then the valve leading from discharge of compressor to the atmosphere should be opened to make sure there is no ammonia in the compressor. Then proceed to remove all suction and discharge valves, marking each cap and other parts so that they can be replaced in their original position. Next remove the head. It is well to place heavy parts on skids or trucks, moving them some distance away from the machine to allow ample room for men to work. Next, loosen the piston nut and unscrew the piston from the crosshead. Use the same wrench to unscrew the piston that you use to loosen the nut or use a clamp on the rod with several holes in it so a bar can be used. In case the threads on the rod are the same size on the outside as the rod, the packing must be removed first to allow the rod to pass easily.

After being removed from the cylinder, the piston and rod should be laid on sacks and covered to keep sand and dirt from getting down around piston rings. The crosshead pin should be removed next. Be sure to drop the wedge in the crosshead brasses before trying to remove the crosshead pin. It may be that the pin has had a shoulder worn or turned on it. In this case you may have to block the connecting rod up slightly to get an even space around

the shoulder so the brasses and other parts will not bind the pin as it is taken out. The crosshead should be handled with care, not allowing it to be rolled on a concrete floor. Now remove the crank brasses and connecting rod, then the main bearing cap and quarter-boxes. It may not be necessary to take out the lower quarter-box unless the front and rear quarter-boxes show marks of having been unreasonably warm or unless the shaft is scored.

Test for Cylinder Alinement

When these things have been done, you are ready to test the cylinder. For this purpose, make a tram of $\frac{5}{16}$-in. round or square steel, ground to a point at each end and just long enough to fit in the cylinder. Move this tram to various points throughout the cylinder to find out if the latter has any low or worn spots and whether or not it needs reboring. If the cylinder is rebored, it is well to test it for taper, after the operation, by using a ring made of ½ in. square cast iron, and of a diameter that will just fit the cylinder. By sliding this ring back and forth in the cylinder, you are sure to detect any taper. This testing ring, of course, is to be a solid ring, not cut like the ordinary snap ring.

As a final test, it is well to stretch a line of very fine piano wire through the cylinder to the main bearing. In order to fasten this wire to the rear of the cylinder, bend a piece of flat steel into a U shape, with about 14 in. spread, boring a hole at the end of each leg. Bolt one leg of the U solidly to the rear of the cylinder. To the other leg, bolt a 1-in. board slightly longer than ½ the cylinder diameter, and slotted for about 3 in. Fasten a similar board to the main bearing at some convenient point so that a wire stretched tightly from one board to the other will be somewhere near the center line of the cylinder. Then, with a pair of calipers, center the wire between the crosshead guides. Now, center the wire in the stuffing box, then test it at the head end of the machine and throughout the cylinder. In this way, a fairly accurate test of the boring job can be made.

In making up a new piston or bull ring, whichever the case may be, to fit the rebored cylinder, check up on the clearance. If there was too much clearance before and you have the new piston or bull ring made the same thickness, you are not correcting your trouble, which is an easy thing to do at this time.

Snap rings for ammonia work should be of the double-turned style, three rings being always preferable to two. Slots for rings should have sufficient depth and the rings should fit just snug enough so that rings can be turned around the piston by hand without binding. If the piston is of the built-up style, the nut should be fastened with a safety setscrew or some device that will not be likely to work out. If the rod is turned, it should be measured with a micrometer to make sure of a true job and should be given a high polish.

Compressor Valves Should Be Inspected and Tested

Compressor valves should next be taken apart and inspected carefully for pits and grooves. It may be necessary to take a cut off the valve. In this case, either the valve disc or the valve seat will have to be renewed. Great care should be taken to see that the same taper is kept that the valves had originally. Also inspect the shoulder of the valve where it fits into the head of the compressor; it may be that this has been leaking and that it must be reground. In grinding ammonia compressor valves, it is well to use a coarse compound first, then a fine compound, until a perfect joint is obtained. Great care must be taken to remove every particle of emery from the valves before replacing them in the heads. After these valves are tight on their seats, test them by filling them with gasoline and allowing them to stand for an hour or so.

Inspect the crosshead pin next and caliper it carefully to see whether or not it is worn flat. Put the brasses into the connecting rod and the crosshead pin into the brasses, then tighten up the wedge to make sure that there is ample room for takeup. It may be that brasses are worn and new ones are necessary, or it may be that a thin liner placed directly against the brass will be sufficient for another season. Make sure the threads in the crosshead are in good condition. Caliper the crankpin and, if necessary, have it turned and the brasses rebabbited. After the old pin has been removed, caliper the hole closely, for, in case the pin has been running loose, the hole is liable to be out of true; in that case the hole should be rebored. In replacing the pin, be sure to warm up the crank so that pin will go in the full amount. It is a good policy to have one or more pieces of steel that will fit loosely in the crankpin hole and that can be kept hot and to place one of these pieces in the hole while the rest of the crank is being heated. Hang a large dolly bar directly over the crank so that in case the pin does not go in all the way, it can be driven in at once. It is well to pack the pin in cracked ice or, if a tank of cold brine is at hand, to hang it in the brine tank. Allow the crank to cool as slowly as possible and, when properly cooled, peen the bead of the pin, repolish it and blow out the oil hole before replacing the brasses. Also blow out the oil hole in the crosshead pin before replacing. After this is done, the piston can be replaced.

Care Is Needed in Reassembling Cylinder

Great care should be taken not to score the rod or cylinder while replacing the piston. If the rod has been turned, it will be necessary to rebabbit the lantern and stuffingbox gland; never allow these to run without a small amount of babbit between them and the rod. After the rod is screwed into the crosshead, move the crosshead towards the crank end and caliper under and over the rod to make sure it will travel on a straight line. The next step is to replace the ammonia compressor head.

In doing this, use only a high-grade sheet packing, generally called asbestos sheet. This can be bought in various thicknesses; $\frac{1}{16}$ in. should be heavy enough for any ordinary work. It is well to use packing that has been treated with graphite; also, on replacing the head, the bolts should all have a treatment of graphite before putting them in place. After the bolts are all tightened, crank and crosshead brasses tightened and main bearing tightened, a feeler should be inserted at various places around the crank to make sure there is no binding between the crank and the main bearing. Next, test the clearance of both head and crank ends of the cylinder with a piece of lead wire, about No. 10. The clearance on a machine with an 18-in. compressor should be not more than $\frac{1}{32}$ in. on the crank end and $\frac{1}{16}$ in. on the head end; the difference is allowed to care for expansion of the rod when it becomes warm.

After the clearance is found to be correct, replace the valves and pack the ammonia rod. For this purpose, my

own preference is for the best metallic packing, using care in placing it. After this is done, the machine should be pinched over by hand to make certain that nothing has been overlooked that might cause an accident when the machine is started. It is well to operate the machine very slowly for a few minutes after starting, just pumping air to the atmosphere. Then pump the air out of the cylinder, close down, feel all bearings and tighten up bolts on the compressor head once more before turning in ammonia. The machine is then ready to operate and, if every part has had close attention, it should run one or more seasons without the slightest shutdown for anything more than to key up slightly on the bearings.

Operation of Reboiling System for Ice Making

By Gilbert R. Wray

SEVERAL systems are in use for making clear ice although the one using condensed steam and reboiling is satisfactory in general.

Exhaust steam should first pass through a vacuum trap filter for removing the greatest amount of oil. This is operated by a seal trap or small pump which automatically works when the filter fills to a certain height. This should be watched closely as great dependency is placed on this filter for removing oil. After going through filter, steam passes to the steam condenser where it is condensed and pumped to the reboiling system, which should be placed either upon the roof of engine room or ice tank roof at the highest convenient place. Then the water will flow by gravity to or through the rest of system, which does away with an extra pump.

There should be at least four galvanized iron tanks built large enough for the system. The first, or No. 1, should be the one into which water is pumped from the steam condenser. In fact all of the tanks should be placed upon a wooden platform over which tar is put to preserve the wood. Should this become oily by overflowing of tanks, sand can be put on top of tar which takes up the oil and greasy slime that accumulates. No. 1 tank usually has a 2-in. galvanized iron pipe, fitted to it a little below the middle of its vertical height and a similar connection is made on No. 2 and connected to No. 1 which discharges into No. 2. The water will then attain the same height in both tanks. No. 2 tank is known as the simmering and skimming tank and is fitted up with from one to three overflows about 4 in. from the top. As the oil and scum arise to water's surface it will automatically drain off, which does away with skimming by hand and is always at work. The water should be high enough at all times to keep the simmering tank at work which is of great importance in ice making. A perforated steam coil is placed in this tank and turned on just enough to keep the water simmering.

Tanks Nos. 3 and 4 are fitted and connected up together the same as the others with the exception of the overflows. Nos. 2 and 3 are likewise connected together.

Three and four are the reboiling tanks and are fitted up with perforated steam coils which permits of better reboiling by allowing the steam to spray into the water; these coils are placed at the bottom of the tanks. These tanks must have steam turned on strong enough to allow the water to boil very hard giving off a good steam vapor, which takes out remaining oil as well as boiling out the air and matter carried in suspension. No. 4 is fitted up with a galvanized iron pipe about 4 in. from the bottom; a globe valve of brass is placed next to tank for shutting it off in case of repairs to pipe line beyond the tank. A brass butterfly valve is also placed next to globe valve, with an arm attached to its stem and operated by a float in the tank, so that a certain water level is maintained at all times.

Water flows from No. 4 reboiler continuing on its way through the double pipe coolers, which must be so connected up to be cut out of service in case of repairs. Here the water is cooled and continues to flow to the filters where it is purified and cleansed.

Filters are generally constructed of the charcoal type. Several kinds can be used. These must be so connected up that they can be cut out of service for cleaning and repairing. The water should enter the top of filter and leave at the bottom. The highest point on filter should have a ⅛-in. pet cock for testing for air in the water and it must be constantly watched and tested. By placing a finger over pet cock and opening it gradually it is possible to determine whether air or water discharges. If water comes out everything is all right; if air comes out the condition must be corrected. Close brass globe valve next to the storage water tank in the ice house and open ⅛-in. valve on top of filter, leaving it open until nothing but water discharges. Next carefully inspect the rest of system and you will no doubt find the cause. After air is out set storage tank valves to normal position.

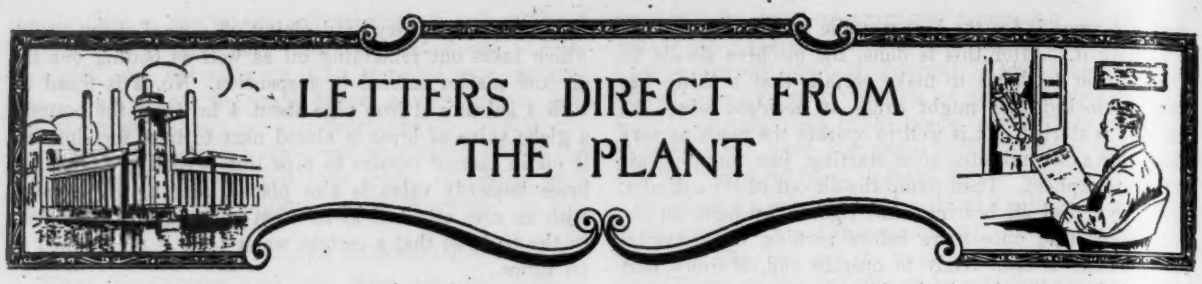
From the filter the water flows to the distilled water storage tank in the ice house and the valve next to this tank is set to maintain a constant level at all times. A pipe line is connected close to bottom, say about 8 in. and hose is attached to this and to the automatic ice can fillers which are regulated to fill cans to the right depth. If the cans are too full, water overflows in the brine tank and weakens the brine as well as freezing the can clear to its top, causing ice puller to lose time as the ice must be chopped away so lifting hooks will take hold. Cans should be filled to a level which is below the level of ice tank brine to insure water in can freezing to its height. Cans should set on a small block of wood secured to bottom of tank to insure circulation of brine beneath all cans.

Ice tanks should be made with division partitions in them but not extending to end of tank by several feet. Agitators should be provided for each division of the tank to secure good brine circulation.

Some tanks use calcium and some salt brine but I believe calcium brine is best for ice making in general and that it should have a specific gravity of not less than 95. The brine temperature should be kept at about 15 deg. F. at its highest, and 10 deg. F. lowest.

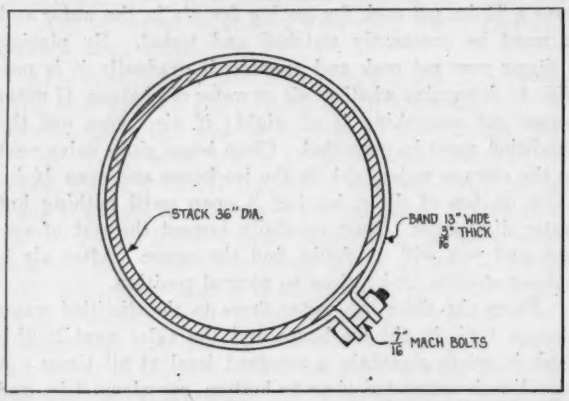
Should the temperature of the tank get too low it will freeze the ice to a brittleness and when placed in the hot water dip tank for thawing it will crack and break to pieces when dumped. Should this happen the ice puller must let the cans set out of tank for a while before dipping as this will greatly reduce the cracking of the ice.

DON'T EXPECT your centrifugal pump to lift water if the joints in the suction line are not tight.



Making Emergency Repairs on a Steel Stack

When a hole caused by rust appears in a steel stack, the stack may be repaired, without shutting down the boilers, by the following method. This method was used in repairing a steel stack 75 ft. high and 36 in. outside diameter, the lower sections being part of an old stack that had blown down, and the upper sections being new.



SKETCH SHOWING METHOD OF CLAMPING BAND AROUND STEEL STACK

In one of the lower sections, a hole about a foot in diameter appeared almost 30 ft. above the roof of the boiler room. It seemed too bad to take the stack down and replace it when the upper sections were new. In order to avoid this, with the resulting loss in factory production during the shutdown, it was decided that an emergency repair could be made by placing a band around the stack over the hole.

Such a band was made, therefore, of $\frac{3}{16}$-in. steel, 13 in. wide, with the ends bent back at right angles for the holding bolts, as shown in the sketch.

In order to get the band into position, it was placed around the stack, then the block and tackle permanently attached to the top of the stack was fastened to the band on the side opposite the bolts. The fastening side was moved up by a man on a ladder to keep pace with the pull of the block and tackle on the other side and, when the band finally covered the hole, the bolts were drawn up tight and the joint between band and stack thoroughly sealed with stack cement. The band had previously been well painted inside and out with stack cement.

This method worked so well that it was used again a few weeks later to repair another hole that broke through on the old stack sections below the first hole.

In using this method, care should be taken to measure the circumference of the stack as near as possible to the section the band is to cover, as the diameter of a steel stack may vary somewhat from top to bottom, and the band must be drawn up tight. An allowance of about 1 in. on the band should be made for the joint. When tightening it up on the stack, use two or three long bolts at the start, changing to shorter bolts as the band tightens and drawing up the bolts equally to avoid stripping the threads.

Waterloo, Iowa. C. C. Hermann.

Considerations in Applying Turbines to Small Plants

With most of the conclusions in Alfred Iddles' article on "Application of Turbines to Small Plants" in the December 1 issue, the writer agrees, although some of them seem to require more explanation. In many cases, there are good reasons for choosing another solution of the problem.

Of these cases, perhaps the principal one is the question of choosing drives for auxiliaries. Among engineers who have not had actual experience with motors, there is apparently a considerable prejudice against extensive use of them for such drives; but where they are properly chosen for capacity and correctly installed, the chances for trouble are much less than with either small turbines or engines. The extent to which auxiliaries should be motor driven depends on the prime mover equipment. If auxiliary powers or breakdown service is available, or a small non-condensing unit is installed on which to get started up after a temporary power interruption, the motor equipment may be most complete without danger or material inconvenience. In such a case, the writer believes in driving only the feed pump and forced draft fan by steam, the former as a safety measure and the latter for convenience of regulation, for, as a rule, as soon as the main unit goes down the demand for steam is off and the other auxiliaries can be spared temporarily. The only possible exception is in the case of the exciter in an alternating current plant; but if direct connected exciters are installed, this difficulty is obviated.

Dual drives are usually an uneconomical system, because if the turbine is direct connected, the speed is usually too low for satisfactory steam economy, while, if a geared unit is used, sufficient steam would be admitted to overcome at least the friction load of the turbine and gearing and to take from the motor, the burden of driving the turbine wheel at high speed through the gearing. Its chief justification is for exciter drive, to get reliability of operation but, as previously stated, direct connected exciters are preferable. As Mr. Iddles emphasizes, it is more economical to maintain the proper heat balance by bleeding steam from the main turbine.

As a general proposition, it is hardly worth spending the money for unaflow engines to exhaust against a high

back-pressure with moderate steam pressures, as under such conditions a good variable cutoff or four-valve engine will give almost as good steam economy, the strong point of unaflow engines being service for which ordinarily a compound engine would be required. The writer also believes that if an accurate test were made of the results of the turbine operating on saturated steam at 125 lb. and bleeding at 40 lb., it would be found that the bleeder steam was producing very little power and that a straight condensing turbine and reducing valve would have been simpler to operate and less expensive.

One disadvantage of the bleeder turbine for textile and paper mill work is that the governor is usually not adjusted close enough; variations in the amount of steam bled will produce noticeable variations in speed, which, under certain conditions, are very annoying. Another point, which merits serious consideration by turbine designers, is an arrangement of a butterfly or non-return valve on the bleeder connection, so connected that the emergency governor will be tripped in case of overspeed. when other apparatus, such as a feed pump, fan turbine, or engine, exhausts into the bleeder line. In such cases it is possible, with light load on the turbine, for this steam to back up into the low pressure stages and cause the machine to run away if the check usually installed in the bleeder line fails to act. Also, the automatic valve regulating the first stage or other bleeder pressure should be provided with stops to prevent its complete closing. This should be done either to prevent a dangerous rise of pressure in the turbine casing or to insure sufficient steam passing to the condenser to maintain speed under average load conditions, even though an excessive demand for bleeder steam should reduce the pressure below that for which the bleeder governor was set with the main governor-valve wide open. If this is not done, the casing should be provided with a relief valve piped into the atmospheric exhaust line of the turbine.

Use of high-pressure superheated steam offers attractive economies in turbine operation, even where it would be necessary to rebuild the entire boiler plant, which would be necessary for most establishments having power plants 10 yr. or more old. But there are serious problems here in replacing the steam piping and minor steam using apparatus throughout the mill or in supplying medium pressure, desuperheated steam for this purpose without interrupting operation.

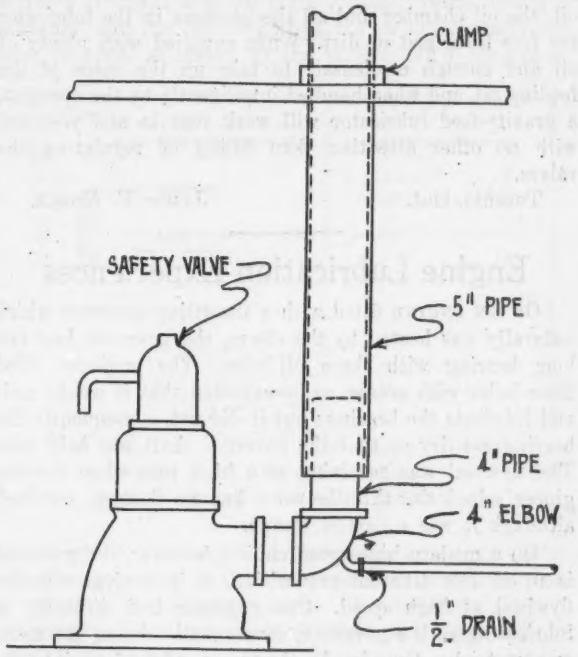
Knowledge of materials and methods for safe operation under such conditions is gradually spreading. Greater precautions are necessary, however, when using high pressures, in purification of feed water, maintenance of steam line joints, valve packings and the like, with correspondingly increased damage in case of failure of any part. The average industrial plant engineer faces a difficult problem in re-educating his working force to handle high-pressure equipment safely and economically.

New Haven, Conn. H. D. FISHER.

Eliminating Strain on Safety Valve Discharge Pipe

IN THE Oct. 1 issue, H. M. Toombs tells of discontinuing the discharge pipe from the safety valve that led through the roof, in order to eliminate the leverage effect which the pipe and fittings had on the valve. In a small central station we eliminated this strain by the method given here. The safety valves had formerly discharged direct into the boiler room, but after they had popped several times and filled the room with live steam, it was decided to run them through the roof.

In doing this, however, we did not attach the discharge pipes to the safety valves. Elbows with close nipples were screwed in each valve outlet, and a piece of 4-in. pipe about one foot long was screwed in the other end of the elbow. A 5-in. pipe, held rigidly at the roof, extended down and slid over the end of the 4-in. pipe as shown. The end of the 5-in. pipe was not allowed to come within 2 in. of the elbow. This allowed the steam to escape into the



DISCHARGE PIPE FITS LOOSELY OVER SHORT CONNECTION ON VALVE

atmosphere and at the same time eliminated the leverage effect on the valve. The elbow was provided with a ½-in. drain, as shown in the sketch, to keep condensation from collecting around the valve seat.

Brockton, Mass. FRANKLIN CHENEY.

Dirty Oil Causes Lubricator Troubles

Many men prefer to use the old type gravity-feed lubricator in preference to the more modern force-feed design. In my opinion, formed from observation in numerous plants, trouble with the gravity-feed lubricator is commonly caused by dirt in the oil. I state this despite the numerous letters I have read giving reasons why such lubricators failed to perform as they should.

Any engineer whose duties take him into many plants cannot have failed to notice the different methods used in storing oil; he must have noted also that the defective methods are not all confined to the small plants. In some places where modern dust-proof tanks are used, the filters for treating the used oil for re-use are properly tended and frequently cleaned. In other places, perhaps as numerous as the former, little effort is made to insure cleanliness of the oil supply. It is not uncommon to see an oil barrel

with the end knocked in and the barrel left open, oil being dipped out, when required with a more or less clean dipper. I have seen men from the boiler room, their hands covered with grit and dirt, go to an open barrel and dip their hands inside to get some oil to loosen the hard dirt. Without doubt this leaves considerable grit in the oil, some of which is likely to be taken out with the next helping of oil required for a lubricator or other purpose. I have seen oil filters which had been allowed to become so dirty that I honestly believe clean oil would have been made dirty in passing through them.

When using a gravity feed lubricator, see that all the joints are tight, whether steam, oil or water. See that the oil, the oil chamber and all the passages in the lubricator are free from grit or dirt. When supplied with plenty of oil and enough condensate to take up the space of the feeding oil, and when handled intelligently by the operator, a gravity-feed lubricator will work year in and year out with no other attention than filling or regulating the valves.

Toronto, Ont. JAMES E. NOBLE.

Engine Lubrication Experiences

ON AN ENGINE fitted with a throttling governor which naturally was heated by the steam, the governor had one long bearing with three oil-holes. The engineer filled these holes with grease, as he expected that it would melt and lubricate the bearing; but it did not, consequently the bearing got dry so that the governor shaft was held fast. The flywheel was revolving at a high rate when the engineer seized the throttle valve but no damage resulted, although it was a narrow escape.

On a modern high-speed engine, however, the governor is an entirely different proposition, as it revolves with the flywheel at high speed. One engineer had difficulty in lubricating such a governor, consequently the engine speed was unsteady. One day he threw a panful of oil into the governor while it was running at full speed. The lubrication was greatly improved but the ceiling and floor showed the effects of it for months afterward. A real engineer will not shut down during working hours, if it is possible to avoid it.

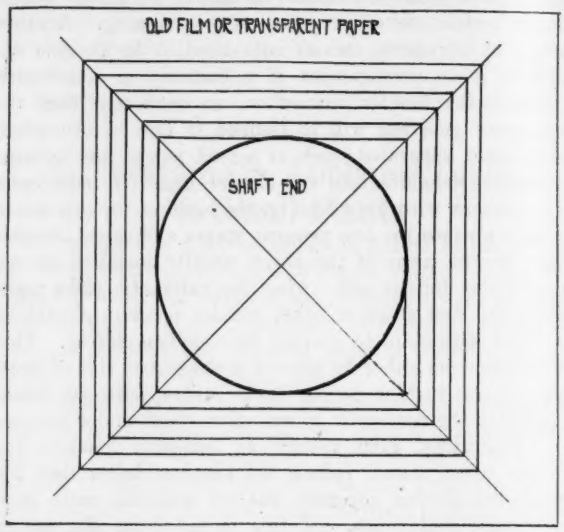
I made special efforts on one occasion to make a perfect fit of the packing around a piston rod. The packing was all right when cold but when heated there was no provision for the resulting expansion and it commenced to heat and smoke, showing that something must be done quickly. The first move was to loosen the gland by turning the nut backward about two turns. During the following 10 min. I used about one gallon of good cylinder oil and finally succeeded in restoring normal conditions without shutting down the machinery.

Several years ago, while in charge of a plant in which there was only one engine, I was puzzled to account for the condition of the crankpin one morning, as the end of it was blackened, showing that it had been used without proper lubrication. Finally I learned that one department had wanted power the previous night and the watchman had started the engine. In such a case, the engineer should be notified, as he alone ought to be authorized to supply the power. If an ignorant watchman is to do it independently of the engineer, confusion is sure to follow and more or less damage will be done.

New Haven, Conn. W. H. WAKEMAN.

Simple Diagram Locates Shaft End Center

WHEN IT IS necessary to locate with some accuracy the center of a blank shaft end and the necessary center square is not at hand, a center gage may be made from an old photographic film, a piece of tracing cloth or a piece of transparent paper, by drawing on it a square with its diagonals, the sides of the square being equal to the diameter of the shaft whose center it is desired to find. Then, when the diagram is held over the end of the shaft so that the sides of the square appear just tangent to the shaft at four points, the intersection of the diagonals marks the center and the shaft may be prickpunched at this point.



METHOD OF APPLYING DIAGRAM TO SHAFT END

A number of concentric squares may be drawn on the same film or paper to make a gage for shafts of various diameters.

Toronto, Ont. JOHN THORN.

How Hot Does a Burning Building Get?

SOME YEARS ago I was making some refrigerating computations and I needed some information in order that I might get the proper results. I wanted the information so that I could figure the proper size of safety valves to use on an ammonia receiver. I wanted to take the worst condition, where an ammonia receiver would be in a burning building under the hottest condition. I wanted to make the safety valve large enough so that regardless of the temperature there would be no explosion so that all of the ammonia could escape.

For the benefit of any others who may want the information I learned from manufacturers of fireproof vaults that they generally figure on a temperature of 1500 deg. F. in making their vaults. Instances have been reported where papers in insulated steel safes have escaped injury or burning in spite of a temperature of 1500 deg. which was registered within the vault or safes. In tests that have been made with heat recorders placed within the safe, this extraordinary temperature has been reached and yet the papers did not burn.

Newark, N. J. W. F. SCHAPHORST.

Power Represented by Pump Discharge

How do you find the horsepower of a centrifugal pump? J. S.

A. To find the horsepower of a centrifugal pump, first multiply the discharge in pounds per minute by the discharge in feet to give you the foot pounds of work done. The product of these two factors will be a certain number of foot pounds per minute, which is a measure of power. One horsepower is, of course, equal to 33,000 ft. lb. per min., so that the horsepower may be found by dividing the work in foot pounds per minute by 33,000. In other words

hp. = lb. of water discharged per min. × discharge head in ft. ÷ 33,000.

The gross horsepower required to drive the pump will of course be greater than this amount, as some allowance must be made for various hydraulic and mechanical losses, which vary in amount depending on the size and make of the pump and are generally expressed in terms of efficiency. Thus to find the gross horsepower of a pump with an efficiency of 70 per cent, find the net horsepower as above and multiply it by 100 ÷ 70. This would give the horsepower that would have to be supplied to operate the pump.

Diagonal Braces Below Tubes Not Recommended in H. R. T. Boilers

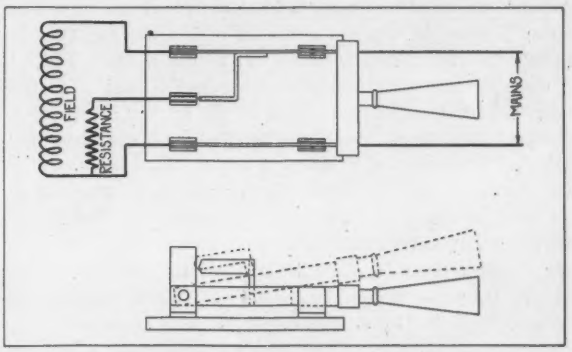
Why do the boiler rules of certain states prohibit the use of diagonal braces from front head to shell in an H. R. T. boiler? R. M. K.

A. In H. R. T. boilers, the use of diagonal braces from head to shell below the tubes in not permitted by the boiler codes of certain states because such construction would necessitate a double thickness of metal and rivets directly over the fire. It is likely that burning of both rivets and shell would occur at this point. Where the arrangement of the tubes is such that bracing of the heads below the tubes is necessary, through braces are used from head to head.

Field Discharge Resistance

What is a field discharge resistance? Is it permanently in the circuit? E. M. C.

A. To lessen the inductive kick produced in the field circuit of a generator when the field circuit is suddenly broken, a field discharge resistance is used. Such a condition would be attained if a switch in the shunt field circuit were opened as the machine was being shut down, because the shunt field current would be reduced from maximum value to zero in an instant and the field flux would also be reduced quickly to zero. In this process the flux would cut the field conductors at a comparatively rapid rate and a high voltage would be generated, which would put considerable strain on the insulation of those conductors. In order to minimize this effect, the field switch is arranged with an extra contact, which throws a resistance into the circuit just as the switch contacts are about to open, as shown in the sketch. This resistance,



RESISTANCE CUT IN JUST BEFORE SWITCH OPENS ALLOWS FIELD CURRENT TO DIE OUT SLOWLY

through which the shunt field current must pass, produces another voltage drop in the circuit, and materially reduces the effect of the inductive kick. The resistance is not permanently in the line. When the field switch is closed, it is out of the circuit.

Starting a Cold Turbine

In answer to W. H. K., who asks in the Dec. 1 issue how to put a cold turbine on the board, the following data may prove helpful. In the operation of the steam turbine, the most important thing is the oil system, therefore it should be started the first thing, making sure that the oilers on every bearing are actually working.

On being satisfied that the oilers are working, the next thing to do is to get the vacuum. If the condenser is of the surface type, see that the pumps are getting oil and that the proper suction and discharge valves and the exhaust steam valves are open, as well as the cylinder drain-cocks. Then turn the steam into the pump cylinder and let it slowly pick up speed. In the case of a rotary pump, the operation is about the same, only we have to look out for the water seals and the priming.

As soon as the vacuum is up to normal, it is time to start the turbine. First make sure that all electrical connections are open and that the proper water seals and oil lines are doing their work. Then open the steam valve slowly and warm the machine up. In case the machine is wanted in a hurry, you will have to dispense with the slow warming and let the steam in. As soon as the turbine is up to speed, take another look around to make sure the oil system is working.

XUM

As soon as the turbine is up to speed, it is time to put it on the board. When the generator is synchronized, plug in the oil switch and the machine is "delivering the goods."

Rochester, N. Y. R. G. SUMMERS.

Preventing Carbon Deposits in Oil-Burning Furnaces

HOW CAN we eliminate or prevent the accumulation of carbon that occurs in our boiler furnaces, in which we burn fuel oil, using the Fess System? W. A. Z.

A. In an oil-burning furnace, an accumulation of carbon may be caused by either of two conditions: first, the burners may not be functioning in such a way as to break up the oil into fine enough particles to produce good combustion; second, there may not be sufficient air admitted to the furnace to support combustion, or the air may be improperly distributed with respect to the flame.

Considering the first item, we suggest that you first make sure that all moving parts of the burner are in good condition and that the rotating tip is clean and not burned. Then put a voltmeter across the terminals at each burner to determine whether or not there is an excessive drop in voltage at the motor. Should you find a considerable drop here, it might be well to increase the size of wire in the circuit in order to get full line voltage at the burner. Our reason for suggesting this is, of course, that if the voltage is low at the motor, it will not operate up to speed, therefore the burner cannot properly atomize the oil.

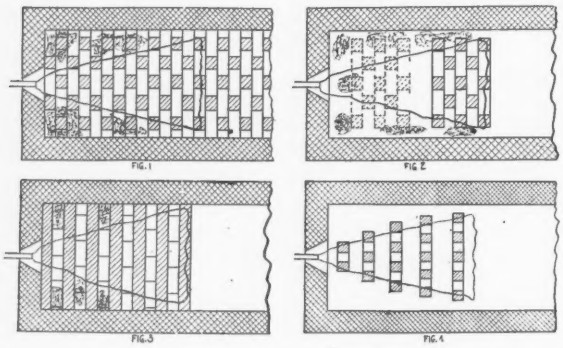


FIG. 1. CHECKERWORK OVER ENTIRE FURNACE FLOOR ADMITS EXCESS AIR, CAUSING CARBON DEPOSITS

FIG. 2. A FAULTY DESIGN, AIR BEING ADMITTED TO ONLY ONE PART OF FLAME

FIG. 3. ANOTHER FAULTY DESIGN, RESULTING IN CARBON DEPOSITS AND UNBURNED EXCESS AIR

FIG. 4. GOOD CHECKERWORK DESIGN, FAN SHAPE OF OPENING ADMITTING AIR ONLY WHERE NEEDED

Some attention should also be given to the oil heating system; if the oil is not being heated sufficiently, poor atomization may result even though the burner is working properly. The oil should be heated to at least 150 deg. F. but not over 200 deg., at a pressure of at least 25 lb. per sq. in.

The second condition—that of the improper distribution and amount of air—will now be considered in more detail. If you are operating with insufficient air, the stack will of course show an excessive amount of black smoke. The remedy for this is to admit more air to the furnace. The accumulation of carbon, however, may take place when there is an excess of air; that is, the air may not be put into the furnace at the right point. Some of the air for combustion should be admitted to the furnace around the burner; the remainder can best be admitted through checkerwork in the furnace floor.

Dampers should be arranged so that the amount of air coming in around the burner and the amount coming through the checkerwork can be properly proportioned. You will probably not experience much trouble in controlling the air admitted around the burner. However, the admission of air through the checkerwork is a little more troublesome to control. If the checkerwork is of uniform construction and extends over the entire furnace floor, as in Fig. 1, it is probable that the flame will not cover all of the openings and no matter what other conditions may prevail, there will be an excess of air.

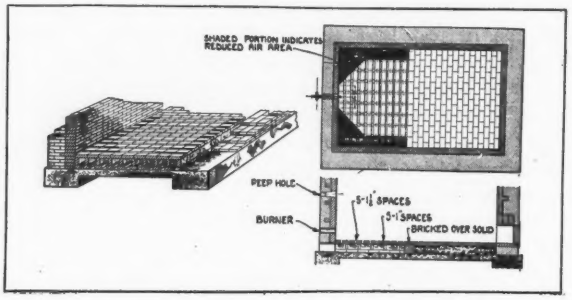


FIG. 5. CONSTRUCTION DETAILS OF CHECKERWORK IN A TYPICAL OIL BURNING FURNACE

If you have large openings in the furnace floor, directly under the burner (Fig. 2), near the end of the flame, the latter will burn hot in the center and deposit carbon at the sides. If these large openings are moved back towards the burner, the flame will burn intensely hot at the center and in all probability will deposit carbon at the sides and out in front of the burner. Transverse openings in the floor (as in Fig. 3) will again give trouble from excess air, whereas if the openings run lengthwise of the furnace, the flame will become stratified and hard to control for proper conditions of combustion.

Transverse openings in the floor beginning near the burner, and extending out about three-fourths of the depth of the furnace will not materially help conditions, because the corners at the burner end of the furnace will not be covered by the flame and the air which comes through will not give a proper mixture. Openings in the furnace floor beginning at a distance of 18 in. or 2 ft. from the burner and extending to the end of the furnace will cause the flame to burn out away from the burner, with the result that carbon will be piled up just inside the burner wall.

Probably the most efficient method of locating the openings in the furnace floor would be to have them extend not quite across the width of the furnace and to start about 9 or 10 in. from the burner tip as illustrated in Fig. 4. The first opening or that nearest the burner can be relatively short. The next opening can be a little bit wider and so on to about the end of the flame. This will give somewhat of a fan shape to the open checkerwork which will conform to the general outline of the flame.

With this arrangement, it would be best to have the openings larger or to space them closer together near the

burner as shown and a little farther apart near the end of the flame. This would provide the greater portion of the air under the flame where combustion begins to take place and would gradually taper off the air supply out near the end of the flame where less oxygen is required to support combustion.

Three things should be done, therefore, to prevent your trouble with carbon deposits. It would be advisable for you first to make sure that the moving parts of your burner are running up to speed and that they are all in good operating condition. Then make sure that the oil is being properly heated. Finally check up on your air supply to see that it is properly distributed so that it will come into the furnace where it is actually needed and where it will enter the flame.

General Formula for Area of Segment

WHAT IS the general formula for finding the area of a segment of a circle when the diameter of the circle and the height of the segment are given? Many hand-books give tables and constants for this purpose, especially for figuring the area of a boiler head to be stayed, but I should like a formula that applies to any case. E. A. R.

A. For finding the area of a segment of a circle when the diameter of the circle and height of the segment are given, the general formulas are as follows: If h equals the height in inches and D the diameter in inches, then—

When $h = 0$ to $\frac{1}{4}D$, area of segment $= h \sqrt{(1.766\ Dh - h^2)}$

When $h = \frac{1}{4}D$ to $\frac{1}{2}D$, area of segment $= h \sqrt{(0.017\ D^2 + 1.7Dh - h^2)}$

Although these formulas are approximations, the maximum error, when h equals $\frac{1}{4}D$, is only 0.23 per cent, so that for all practical purposes the formula is entirely satisfactory. It applies to any case and is not difficult to use.

In the case of a segment of a boiler head to be stayed, the Massachusetts Boiler Rules give the following formula for this purpose:

$$A = (4H^2 \div 3) \sqrt{[(2R \div h) - 0.608]}$$

In this formula A equals the area of the segment to be stayed in square inches, H equals the distance from tubes to shell minus 5 in., R equals the radius of the boiler minus 3 in.

This formula may be used only in figuring the area of a segment to be stayed in a H. R. T. boiler but does not apply to any other case whatever.

Corrosion in Steel Stacks

IN THE Nov. 1 issue, C. M. A. wants to know the cause of the deposit in his stack and whether or not it has a deteriorating effect on the steel, also what may be done to prevent this deterioration.

I have noticed this condition in several instances and I have talked with old steamboat men who seem to think that it is a common occurrence. This is probably because they always take considerable pride in their stacks and keep them clean and shiny. However that may be, the steamboat builders have taken steps to eliminate this disagreeable feature.

Taking the questions in their order, the first point is the source of this deposit. It is a condensation out of the flue gases due to the outside temperature being lower than the inside temperature of the stack. The atmosphere when heated can carry more moisture than when at a low temperature. As the high temperature gases within the stack come in contact with the stack wall, a cooling effect takes place, reducing the moisture-carrying capacity of the gases. The moisture thus condensed must deposit somewhere or fall back into the stack. In fact, some of this moisture does start back down the stack, but in doing so follows the steel shell. This moisture comes in contact with the small ledge formed by the lap of the stack sheets and, if this lap is not moisture tight, it runs through to the outside. Here it dries up after a while, leaving a yellowish deposit on the stack.

Just what this material is composed of would be more easily determined by having an analysis made of the coal used. In general it is thought to be caused by the presence of crystalline and plastic sulphur in the fuel, the latter condensing to a gummy substance. If combustion is complete but excess air is present, the gaseous products will carry free oxygen, which may combine with the necessary amount of sulphur and hydrogen to form sulphuric acid. Sulphuric acid, of course, has a deteriorating effect when in contact with metal.

Since the correspondent states that the deposit on his stack has an acid reaction and resembles burned sugar in appearance and smell, it is possible that his trouble may be due to a local fuel condition and has no connection with my own investigations in this respect. It is also possible that there would be no deteriorating effect on the metal due to this deposit.

I referred above to the steamboat practice in preventing the discoloring and deteriorating condition around the joints of the stack. This practice consists in reversing the stack construction from that ordinarily followed. Instead of the laps going with the flow of gases up the stack they are constructed crosswise to the flow. I supervised a job some time ago where this method was followed out. The condensation in this case will go on just the same as formerly, but as it flows down the interior of the stack, the liquid will collect on the edge of the lap in large beads and then drop off. In dropping, this liquid is thus clear of the stack and either falls clear to the bottom or is picked up again by the higher temperature gases below. At any rate, the liquid cannot run through the joint to the outside.

Of course the cry against this stack will be that the effective diameter of the stack is reduced. While this is true to the extent that the edges of the lap will retard the gases next to the wall, we note that standard stack design provides for a layer of gas 2 in. thick next to the chimney wall; this layer has no velocity, therefore reversing the laps seems defensible. Experience with this type of chimney seems to justify the reversal on account of the increased life of the stack alone.

Waterloo, Iowa. C. C. HERMANN.

Asphaltum Paint Is Shellacked Before Repainting

IN THE Dec. 15 issue, G. A. K. wants to know how to prevent black asphaltum paint from showing through lighter color paints applied over it. If he will shellac the pipe before putting on the lighter colors, he will have no further difficulty. C. D. S.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Looking Toward 1925

Our recent presidential election definitely settled any September or October doubts regarding the character of our government for the ensuing four years. And the recent industrial reaction to this settlement has proved the nation-wide faith in conservative principles.

We know of several large contracts that were purposely held up until election returns were either assured or "in." Business in general wanted to be sure that socialism would not tie the country into a knot before going ahead with ordinary buying and commercial activity. Having that assurance, we are now tightening our belts and taking stock for a period of sound, healthy progress.

That we are justified in so preparing for good business, nobody doubts. We know of no time when our industrial stage was better set. At no time in history has the United States been better prepared to play the leading role. Seldom has the economic horizon been so free from clouds. Viewing our condition from any angle—from Babson's charts to the bank book of the Iowa farmer—no sounder basis for optimism can be found in the past 50 yr. Nor is there any indication that our period of industrial health will be short-lived. Taken sanely and without undue expansion or inflation, the prosperity that is now ours should extend over a period of years.

Industry is full of people who put off building a new addition—who hesitate to install a new system—who delay the stocking of raw material—because they think "the time is not ripe." It remains for the Astors to buy farms on Manhattan Island, the Fords who continue to build new plants, the Carnegies who add new units, the Hills who push their rails northwestward, the Rockefellers who dig new holes, to teach us that confidence and faith in the future of the United States pays dividends.

There are times, of course, when individual plant extension, or specific action, is not propitious. But in the long run we lose more than we gain by being fearful of the morrow.

What Is Being Accomplished in Other Fields

One engineer has found a way to substitute a single apparatus for a dozen or more of the present type of radio aerials. This not only means the elimination of the vast mileage of copper wire aerials now employed, but in the very near future all new apartments and all hotels will have a universal aerial from which a lead will be brought into every apartment or into every room. The State College of Kansas has incorporated in its curriculum a course on radio. In a few years every college and university will have a radio course.

In 1789 the average span of life was about 36 years. Now it is 55. It is not a dream to say that by 1950 it will be 65 years.

In Washington they have found a way to control positively the blossoming or seeding of plants. In one experiment with a common garden variety of radish, which plant was subjected to electric light at night as well as sunlight during the day, the radish continued to grow at its normal, rapid rate for over a year. The result was a crisp, well-flavored radish, as large as a sweet potato. As soon as the night light was turned off the radish seeded and ceased growth.

Over in Japan they are growing oyster pearls. This is done by prying open a live oyster, dropping a single grain of sand into his shell, then releasing the oyster for normal life. The grain of sand forms the nucleus around which a pearl grows and develops. It takes about 5 yr. for a pearl to develop to ordinary size.

The outer skin of a shark is now dried and used by cabinet makers for polishing hardwood or ivory. (The writer is going to get a piece for his head.) The inner skin of the shark lends itself admirably to the manufacture of waterproof bags, belts, purses, etc. The eyes of the shark, when treated chemically, make beautiful ornaments for jewelry. Most of the so-called cod-liver oil sold is, in reality, shark-liver oil.

A new metal has been produced. It is a combination of copper-tin-bronze in which graphite has been incorporated. It is so hard that it will turn a lathe tool, yet so porous it will absorb oil like a sponge. It will be used extensively for installations that have heretofore lent themselves with difficulty to lubrication.

Artificial silk is now made from spruce wood. Non-tarnishing silver is here. Waste slate is now being pulverized and incorporated into rubber to provide greater wearing qualities for boots, rubber heels, tires, etc. A new process for fusing old and new rubber does away with vulcanizing cement. A new method of pouring concrete permits house construction that is superior to, yet 20 per cent cheaper than, brick construction. The first insulated house to be heated with gas was recently advertised in Rochester. Perfection of this principle spells revolution to domestic heating and an end to the criminal waste involved in burning coal raw, at least so far as domestic use is concerned.

Saw-dust is now used to make a non-rot wood. Florists can now perfume odorless plants by means of grafting. This means that worm-wood may be made to smell like violets in the future. Pineapples require iron for proper growth. Growers of this kind of fruit now spray the leaves with an iron sulphate, thus artificially feeding the plants and speeding their growth.

A discovery in the science of mixing iron and steel makes possible the transmission of cablegrams by wire at four times the speed now possible. Harvard has recently produced a serum said to be fatal to the pneumonia germ.

In Europe they are transferring spider webs to gummed cards. These they treat chemically to harden and waterproof them, after which treatment they are used for trimming on women's hats. A high-grade gasoline is produced from eucalyptus oil—in Australia. A man in California recently melted bricks by focusing the sun's rays with mirrors. In Colorado one artesian well gives forth hot water. This water is made to circulate through the buildings of the town thus heating them at practically no cost. In France a huge windmill (revolving in a circle of

130 ft. diameter) generates 90 hp. in a 13-mile wind. Electricity has been generated by ordinary windmills (experimentally) in a suburb of Chicago for over two years. Development of this scheme would be most far-reaching.

Next month we will tell you of some of the things that are not yet actual facts but which may be expected—soon.

Saving $350 a Month

Through systematizing their reclaiming department, the Consolidated Water Power and Paper Company of Wisconsin Rapids has effected a saving of $350 a month, according to the Paper Industry. Believing the idea might be extended to other mills and factories, we quote:

"Under the 'reclaiming department' comes the cleaning of the mill, salvaging of used material, inspection of fire equipment, elevators, scales and, according to schedule, the painting of the mill.

"In order to keep the mill clean, one man is placed in each department. In addition to cleaning, it is his duty to keep everything picked up and turn everything of value in to the reclaiming department. In this way the mill is kept clean and nothing is thrown away. The material turned in by the cleaners is inspected and that which is good is assigned to the storeroom. Odds and ends not standard equipment are kept in the reclaiming department with other old material.

"Inspection of certain mill equipment is carried forward on schedule. This schedule is as follows:

Monday, fire equipment; Tuesday, scales;
Wednesday, ladders, chain blocks, guards, railings;
Thursday, trucks; Friday, elevators;
Saturday, floors and electric light extensions."

If such systematization effects a $350 monthly saving in one mill, an equal amount of thought and study of the average "reclaiming" or "cleaning" department in your plant might easily effect a worth while economy.

Trade Secrecy

In a recent trade dispatch appeared:

> "A secret formula for making dye by a method said to require only a fraction of the usual cost has been carried to the grave by a London pauper, Robert Culver, who learned it from a German relative years ago, when he brought it to England, where he organized a dye manufacturing concern. The concern, however, failed through dishonesty of some of its officials and Culver was reduced to poverty. He died recently in the poor-house without telling anyone of the process."

Of the value of the secret in question, we know nothing. The instance serves, however, as an opportunity to emphasize again that secrecy in industrial, commercial or scientific work belongs to the dark ages—that it has no place in modern affairs.

There still live those who jealously guard all the minute details of any formula or process or method which they have discovered in their particular work. Some will hardly permit a visitor to their plants or factories for fear a bit of knowledge regarding their processes or methods might be disseminated. We know of four manufacturers who would no more allow a staff member of one of their competitors to visit their factories than they would partake of cyanide. One is a maker of metal products, one fabricates lamp-shades, another makes window-sash and the fourth is a paper manufacturer. Very bluntly and frankly speaking, we think this is simon-pure narrow-mindedness. As a matter of fact, the "secrets" so jealously guarded by these operators are not such secrets as they imagine. All a competitor has to do to gain complete knowledge of the other's processes or methods (if need be) is to release a trusted employe for work in the competitor's plant, through whom the information is gained, accurately and in full.

One of the reasons why the automotive industry has made such great strides toward quantity and economical production, in such short time, is because trade secrecy in the automotive industry is almost unknown. It is not difficult to gain access to any of Ford's plants. His methods and his processes are open to any legitimate investigator. Westinghouse or General Electric welcome writers or research men. Yet they do not seem to be suffering financially or morally therefrom.

A good idea, like anything else, grows stale and deteriorates through lack of ventilation. Plant your ideas like flowers—where your neighbors can see them. For the industrial idea, the trade journal is the best flower garden.

We Leave You to Find the Moral

Not long ago we had the pleasure of reading a letter received by a trade journal editor. It was from one of his field men and told an interesting story. The editor kindly consented to let us reproduce it below, names omitted, of course.

"....Had a great time with Mr. ——— of the ——— Company today. I waited all morning for him to show up and, when he finally did come in, he was all fussed because some of his equipment was down for repairs.

"Finally he got around to talk to me, and said he wasn't interested in our periodical and had ordered the subscription stopped. He said it was a d——d shame the way the mails were cluttered up with stuff that nobody ever read.

"I told him that nobody was forcing the journal on him; that, if he wanted it, he would have to pay for it like everybody else who gets it; that we would probably manage to continue business without his subscription. I started to leave, but he calmed down and became apologetic, finally saying the real reason he didn't continue his subscription was that business was bad and they were cutting down expenses, including advertising and subscriptions to all trade papers.

"I said he was the first producer in his district who had told me business was bad. He replied that any producer who said otherwise was a liar. I told him that I *knew* neither 'Smith' nor 'Jones' would lie to me about business conditions; and then he admitted that 'Smith' and "Jones" might both be doing good business *because they had some big contracts to fill.*

"I subsequently got a line on this firm. Their equipment is all worn out, much of it being obsolete. They inherited the business from their father, and I take it, have gone on—putting nothing in and taking everything out—until they have left a pile of machinery fit only for the junk pile. And since they are the kind of people who cannot find time to read trade papers and who can't afford to advertise I do not wonder at their doing this. I believe the sheriff's door is not far from their office."

EDITORIAL COMMENT

Reduced Boiler Rating Made Possible by Forced Draft

Forcing the furnace far beyond what had previously been customary has become common practice in the larger power plants during the past 10 years and it was learned that boilers had really been loafing along at about half the load they could carry economically.

Just as the use of steam turbines in place of reciprocating engines has reduced the space requirements per kilowatt of generating capacity, the modern practice of forcing boilers beyond their rated capacity has cut in half what was considered the necessary capacity a few years ago.

For these changes in practice which have resulted in a reduction of the first cost of a boiler plant, considerable credit must be given to the use of forced draft and with the increased use of fans for furnishing this forced draft has come a marked improvement in the design of fans, the methods of driving them and the control features which have made them a success in controlling combustion in boiler furnaces. It is interesting to note how rapidly these developments have taken place and difficult to predict, as stated by Mr. Booth on other pages of this issue, what demands will be placed on forced draft equipment in the future.

Economy of Petroleum

Efficiency in the use of our petroleum resources depends upon the important factors of production, distribution and the manner in which petroleum and its products are used. These are problems which not only face us today but which will become more important as time goes on. The seriousness of these problems, as they must be confronted in the future, is largely dependent upon the farsighted and unselfish attitude which is taken at the present time. We can think back with shame upon the way our timber resources have been wasted and still we must recognize that at least in some measure our timber supply can be augmented by the planting of new trees. That advantage does not exist in so far as our petroleum resources are concerned, for once the natural supply is gone it cannot be replaced.

Production and distribution must be met by the producer in accordance with the law of supply and demand and the peculiar conditions which govern the recovery of petroleum from the earth. Gas pressure, pumping costs and the attitude of adjoining producers are factors which must be considered. The same problems need no consideration in the production of coal for the reason that the supply will always be available to be extracted when and in such quantities as may be desirable by the individual producer.

If we are to leave the production and distribution problems up to the producer, we as engineers still must shoulder the great responsibility of proper and economical consumption. The problems of the day are to improve the means by which oil is used; to design more efficient engines and methods of burning oil under boilers; to improve the devices used for lubricating machinery and also to economize in the use of lubricants and fuel oil.

Engineers can help still further if they will determine where oil is being used for purposes or in localities which could be as well or better served by some other fuel or substance, and conversely they should determine what industries could more profitably use oil. The price of oil varies with production, therefore it will be an advantage to follow these variables and by so doing to effect economies and absorb at least a portion of the overproduction. As production falls off and prices increase, it is the engineer's economic duty to find out what industries, plants or processes can use substitutes to an advantage.

Demand for petroleum and its products is increasing daily and with the supply a fixed quantity, it certainly behooves every engineer, as a good American citizen, not to discontinue the use of petroleum products but to use them economically and to the best advantage.

Definite Training Program Develops Future Plant Executives

Most discussions of power plant installation, operation and repair presuppose the existence in the plant of a force of properly trained operators. Modern power plant machinery is, in many cases, automatic and foolproof but successful plant operation still depends, and will continue to depend, on the loyal, intelligent efforts of a force of experienced men who know what to do with the plant machinery to get the best results from it.

By far the best method of developing such a force is to build up and train the men in the organization to meet larger responsibilities. That it is possible to do this, without undue expenditure of time or effort, is shown by the experience of a certain company operating four power plants that furnish light and power to a large southern city. The duties of each job in this organization and the qualifications necessary to fill it are carefully analyzed and, when a vacancy occurs in a position above that of common laborer, a man is selected from the organization who has the training and experience necessary, instead of hiring a man from outside.

In this company, too, a grammar school education is required of applicants for all but four jobs, not because it is necessary in all of them, but because the company is looking to the future. The employe's entering qualifications and subsequent progress show his adaptability to a certain class of work, therefore he is aimed at a responsible position in that work. The power plant management prepares for him a definite plan of advancement, so that at the end of a certain period, he should have arrived at a definite place. He is advanced from his first job to and through jobs that will equip him for that distant goal. He learns each job thoroughly. Often his progress may be slower than he believes necessary. The final result, however, is that when he is advanced, he is equipped in training and experience to handle his new work.

Most important of all, every effort is made to treat the

man as an individual, to avoid rigid rules for promotion and to fit the job to the man rather than the man to the job. The result of this policy has been a marked raising of efficiency of operation, a lowering of costs and a loyalty and spirit among the men that cannot be obtained simply by spending money on welfare work or plant conveniences.

We are fully in sympathy with such methods as these. They can be applied in any industry, but they apply particularly well in the power plant. It is better for all concerned to give an employe much of the training he needs within the organization and to show him that his is not a blind-alley job. As long as skilled, experienced men are needed in the power plant, an intelligent interest in them on the part of the management is fully as important as any other factor in plant operation.

Off Duty

"Mr. Jones, Havana is calling you."

Mr. Jones has just answered his telephone and hears this simple announcement. Mr. Jones, by the way, is one of our hundred-and-ten million inhabitants, and lives in a little outpost of civilization, or, if you please, in any one of a hundred teeming cities; or perhaps, he is enjoying the balmy breezes of Santa Catalina off the coast of southern California, 5700 mi. from Havana, who, Mr. Jones has just been informed, is calling him.

Six simple words! Yet this brief message represents perhaps, the greatest achievement that the human intellect has been able to accomplish.

In all probability, Mr. Jones is a phlegmatic person, perhaps like you and me; just an ordinary everyday citizen who accepts everything as a matter of course. "Mr. Jones, Havana is calling you" means nothing more to him, than the possibility of transacting some business. Being unromantic, it probably never occurs to him that behind those six words lies one of the most stupendous triumphs of modern science; that in order that the long distance operator may say these six words there has been 49 yr. of painstaking, often heartbreaking research. Millions of men have labored through sunshine and storm; hundreds of millions of dollars have been spent. It has required alert, highly trained minds to bring about this marvel. Instead of having to wait, as his grandfather did, weeks for the pony express or as his father, days for the transcontinental mail, Mr. Jones is able in a period of 15 min. to annihilate 5700 mi. of space.

Without doubt, Mr. Jones' viewpoint would be changed if, perchance, he could visit a certain building in downtown New York. For here would be unfolded to him the Arabian Nights story of speech transmission, and his phlegmatic shell would drop from him as a silk worm sheds its cocoon.

No man or woman can visit this dominating structure of tapestry brick without becoming a romanticist. Officially it is known as the Walker-Lispenard Building, but it is often referred to as the "Tower of Speech" or the "Heart of Long Lines." For in this building center all the long distance lines from all parts of the country. It is this building which supplies the connecting link, between Havana, and Mr. Jones in California, when Havana is calling him.

The Heart of Long Lines forms the basis of an extremely interesting article in the December issue of the Western Electric News. It is from this description that the material contained in this "Off Duty" talk was abstracted. In the article referred to the writer puts forth an interesting analogy between the "Body of Speech" and the human body.

The "Heart of Long Lines" may be compared to the human heart in many ways. Running out from this building, are 3000 underground trunk circuits. These circuits which spread out radially to 150 local telephone offices in New York City and its environs may be termed the veins of speech. Then there are 1100 circuits, arteries, if you please, extending to long distance telephone offices in various cities throughout the country, which in turn have their smaller capillaries of speech, and are ultimately nourished through the "Heart of Long Lines" at Walker Street.

In this last group of major circuits there is an artery which might be termed the "Aorta" or the longest artery in the "body of speech." This circuit gives direct communication over a single circuit with Havana, Cuba, 1600 mi. of land line and 110 mi. of submarine cable. As might be expected this circuit plays a major role in the "Havana-Jones Act."

It is also interesting to know that by a switch at Chicago, a circuit may be set up between New York and San Francisco of 3360 mi. Also, assuming that Mr. Jones is on Santa Catalina and a call comes from New York, the connection switched at San Francisco and Los Angeles would be 4000 mi.

Feeding this great heart at Walker Street are about 20,000 outgoing calls to points throughout the United States and portions of Canada, Mexico and Cuba, with approximately the same number of incoming calls. In other words, 40,000 calories of speech nourishment.

"Long Lines" is further like the human body in that it possesses a soul. This soul is composed of 1500 men and women who, with unparalleled devotion to duty and with the highest type of mental equipment toil day and might to render service and to make neighbors of one hundred-and-ten million human souls.

We have merely touched upon one phase of the "Heart of Long Lines." Space does not permit us to describe the classrooms where operators are trained, the intricacies of the repeater and ringing apparatus on the second floor, the wire chief's domain on the third floor where all the ills that Long Lines is heir to are diagnosed. It would be interesting to describe in detail, the methods used in receiving and routing calls and the pneumatic tube systems which handle slips of paper without their being placed in a container, but we must be content with the mere mention of these. And so on, up through the entire twenty-five floors, we would find something marvelous on each. The man scientifically inclined would no doubt love to linger in the laboratories of the A. T. & T. Co., where all the development and research work is done. On the 19th floor is a semi-mechanical board which takes care of calls from small offices out of New York, assigning than by means of keyboard operation, either to machine switching or manual offices.

After this, if he could visit all this, do you question whether Mr. Jones would be indifferent to the real meaning of "Mr. Jones, Havana is calling you."

Some one has said, "Speech is like tapestry." If so, what a mantel of beneficence this "Loom of Whispering Wires" is weaving for mankind.

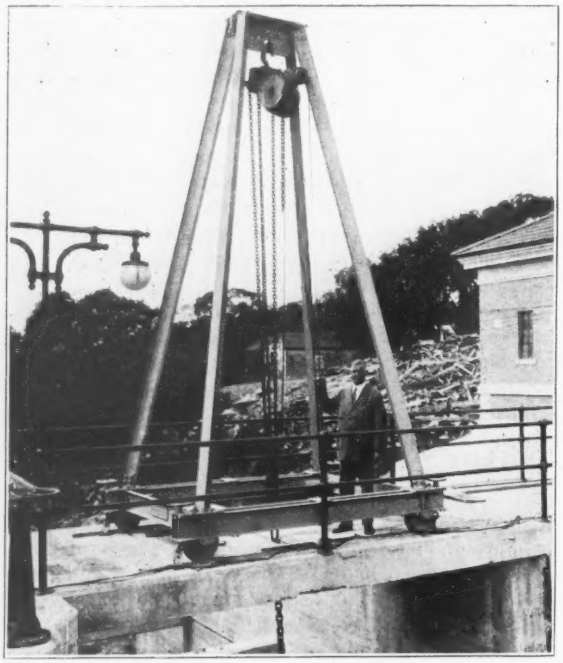
Yearly Index

INDEX for Volume XXVIII of Power Plant Engineering is now prepared and will be sent free to subscribers upon request.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Water Gates Opened with Power Driven Chain Hoists

TO SIMPLIFY the raising and lowering of the water gates at the Oakland and Waterville plants of the Central Maine Power Co., the arrangement shown in the



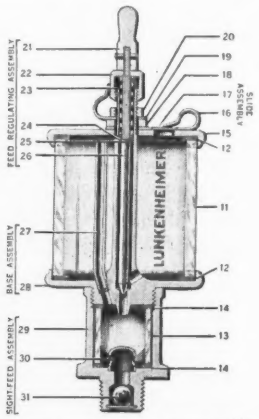
MOTOR OPERATED CHAIN BLOCK IS SUSPENDED FROM A MOVABLE FRAME

photograph reproduced herewith has been developed. It consists essentially of a structural steel frame which is mounted on a channel section truck. A track has been provided with wheels so that the frame may be moved from one gate to another, thus avoiding the necessity of duplication. By referring to the illustration it will be noticed that a track clamp is provided at each corner of the truck frame. By means of these clamps the structure can be clamped and securely held at one point.

Suspended from a gusset plate at the top of the frame is an electrically driven chain block, made by the Motorbloc Corp., which furnishes the power for handling the gates. The load hook is attached directly to the gate and the motor control is brought down so that it is within easy reach of the operator. The capacity of the chain blocks which were installed are 8 T. each, these being of sufficient capacity to open the gates even though they may be loaded with ice.

Sight Feed Lubricator for Internal Combustion Engines

IN A sight-feed lubricator for use on the cylinders of internal combustion engines, recently brought out by the Lunkenheimer Co., of Cincinnati, Ohio, a ball check is used to retard the back pressure from the engine. The ball check is shown at 31 in the accompanying illustration



BALL CHECK RETARDS BACK PRESSURE FROM THE CYLINDERS

and the baffle cap, 30, diffuses such pressure which passes the ball, 31, thereby insuring the perfect formation of oil drops and preventing bespattering of the inside of the sight-feed glass.

Starting and stopping of the oil feed is controlled by the lever 21. When the lever is raised to a vertical position, the feed is open, and when placed in a horizontal position, the feed is closed. The maximum feed is obtained by setting the lever at an angle of 45 deg. to the feed stem.

Regulation of the oil feed is governed by the knurled cap, 22. Turning this cap to the left increases the oil flow and to the right decreases it.

Severe vibrations will not affect the setting of the snap lever, 21, nor the feed regulating cap, 22, the latter being held from turning by the engagement of the spring, 19, with the knurled periphery of the cap. Neither will starting and stopping of the feed by means of the snap lever, 21, affect the setting of the regulation controlled by the cap, 22.

The filling hole is large and enables convenient filling of the glass body reservoir. It is covered by a slide, 16, which is provided with a plate, 17. This plate tightly covers the filling hole when the slide, 16, is in closed position, due to the curved handle of the slide bearing upon it. The base, with integral center post, and its cover, are

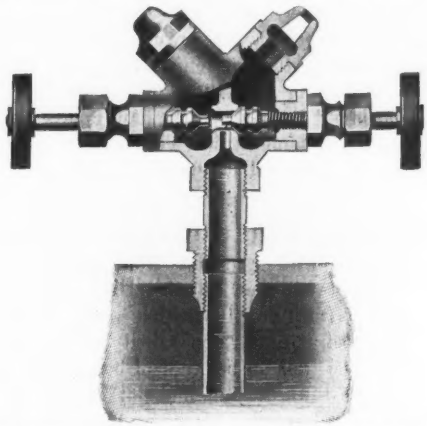
made of bronze. The cover 15 is securely attached to the center post by a substantial retaining nut, 18. The sight-feed base, 29, is heavily constructed and a clear vision of the dropping oil is provided.

New Fusible Plug Has Duplex Feature

IN THE Duplex fusible plug, recently placed on the market, two fusible plugs are so connected that neither of them can be shut off from service until the other one has been connected. This is accomplished by putting a projection on each valve stem as shown in the illustration.

To prevent molten metal from a fused plug from falling on the threaded part of the valve stem, a shoulder with grooves has been provided in the plug cap, as shown. These grooves are designed to direct the flow of the metal into a basin in the plug chamber.

Another feature of this device is the ease with which plugs may be renewed in it. The plugs are inserted in the caps, which can be removed easily with a wrench. All



VALVE STEM PROJECTIONS PREVENT CLOSING OFF BOTH PLUGS

parts of the device are constructed of brass and are tested by the manufacturer, The Hackman Co. of Milwaukee, to stand 300 lb. hydraulic pressure.

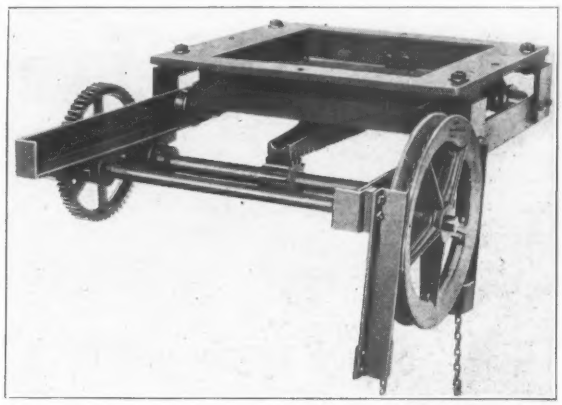
This plug is inserted in the top of the boiler. A brass bushing furnished with the device is screwed into the boiler shell, with a ½-in. pipe leading from the bushing to the lowest permissible water level. Then the Duplex fusible plug is mounted on the nipple as shown.

Ash Gate Operated Through Rack and Pinion

IT IS a recognized fact that ash gates are subjected to extremely abusive treatment, as the result of which this important auxiliary to an ash disposal system is frequently the cause not only of considerable annoyance but also a source of maintenance expense. The materials entering into the construction of the American ash gate, as made by the Conveyors Corporation of America, are principally grey iron and steel. The gate frame and the gate frame proper are made of grey iron of heavy construction, with such surfaces requiring accuracy in operation fully machined. The gates are so designed that none of the moving parts come in contact with the descending column of ash at any time.

Heavy steel members forming the runway for the gate rollers are bolted to the frame, limit stops being provided to prevent over-travel of the gate on either end of the extreme open or closed position. The rollers on which the gates operate are machined castings fastened to the gate by means of steel pins bolted into spot faced and reamed pads cast on the sides of the gate. The sides of the gate are so designed as to enable them to travel in a straight line at all times without excessive side play.

Hand operated gates are provided with a flat rack fastened to the under side of the gate casting. A heavy pinion, keyed on a cross shaft with a gib key, meshes with the rack and the operation is effected by means of a crane chain operating in a rag wheel at the end of the cross



DOUBLE GEAR REDUCTION IS USED ON THE LARGER SIZES OF GATES

shaft. In the case of the smallest gate manufactured, power is transmitted direct through this cross shaft and pinion to the rag wheel. In all sizes above this an additional cross shaft and pinion is furnished whereby the gearing is compounded. This enables the operator to operate the gate under difficult conditions. All rollers as well as shaft bearings are equipped with self lubricating bronze bushings, thereby eliminating necessity for frequent attention in this direction.

Gasoline Driven Ventilating Fans of Small Capacity

ANNOUNCEMENT comes from the B. F. Sturtevant Co. of a new portable ventilating fan, driven by a gasoline engine, which will provide ventilation where fresh air is wanted and electricity is not available. Designed primarily for the ventilation of telephone manholes, these units are equally applicable wherever conditions make it inconvenient or impossible to use electric-motor-driven fans. These blowers are available arranged either for direct drive or for belt drive.

The engine is the Briggs & Stratton Co.'s "Fullpower," single cylinder, 4-cycle, air-cooled, developing ¾ hp. at 1800 r.p.m. The tank is located in the base of the engine and as the magneto is contained in the flywheel, no batteries or auxiliary tanks, for either gasoline or water, are necessary. Speed regulation, providing for constant speed, is obtained by means of an adjustable governor. The blow-

er will deliver volumes ranging from 775 to 1050 cu. ft. per min. with engine speeds of 1300 to 1750 r.p.m. For cases where the smallest volume delivered by the direct-drive unit would be too great, the belt-drive unit can be used. It will deliver volumes ranging from 300 to 1250 cu. ft. per min., depending upon the pulleys used on the engine and the fan.

Concrete Dam Made Watertight

RATHER A UNIQUE piece of work in solidifying and protecting against further damage a heavy concrete structure, was recently undertaken on a gravity concrete dam across the St. Croix River in the state of Maine. Due to difficulties of constructing this dam in extreme cold weather, there were inherent defects which permitted a

DEFECTS IN THE DAM PERMITTED A LARGE AMOUNT OF LEAKAGE

large amount of leakage. This amounted in volume all the way from a trickle, due to seepage, to actual streams spurting out to some distance. The action of frost during a period of years on both the water coming through the flash-boards and running down over the downstream face and on the water going through the body of the dam, was such as to tear away large parts of the concrete on the downstream face, this damage becoming progressively worse each winter.

Investigation by a diver showed no such deterioration on the upstream face which was continuously under water below the bottom line of the flash-boards. The first thought was to fill up the holes on the downstream face and then cover the surface with a smooth facing by means of cement-guns. Obviously this would have been a temporary expedient of questionable value so long as the body of the dam was saturated with water. This water would freeze and push off the concrete facing.

To dewater the lake above the dam was ruinously expensive and to cofferdam the upstream face was a matter of extreme difficulty owing to the water logged timber and other rubbish that had accumulated. It was decided, therefore to try to solidify the body of the dam by impregnating it with cement grout.

One of the difficulties anticipated was the matter of slime which covered the downstream face and extended into the cracks and crevices to an unknown depth. This slime would have to be removed before the impregnating cement or grout would bond to the old concrete. Another difficulty was the stoppage, on the downstream face, of leakage through the flash-boards. Finally it was decided to build a movable cofferdam and float it into place. The pressure of the water held it firmly in place after removing the flash-boards and what little leakage there was through the cofferdam was gathered into the gutter and piped free of the downstream face with a 2-in. iron pipe.

By a process of impregnation under heavy air pressure, the structure was first cleared of slime with a weak solution of potassium permanganate, which almost instantly oxidized the slime wherever found, leaving clean surfaces. Cement grout with various admixtures of accelerating or retarding compounds was then forced in until the downstream face was entirely dry. Reinforcing mesh and rods were then secured to the face by means of anchor bolts. Concrete, consisting of one part Portland cement and three and one-half parts of sand, was then "shot" in place, filling all cavities and coating the entire surface as shown in the picture.

Before applying the concrete it was quite definitely shown by various investigations that porosities, cracks and crevices were definitely filled and sealed. It is believed, therefore, that not only is the downstream face thoroughly protected against further action of frost due to penetration of water flowing over the downstream face through the flash-boards but the body of the dam is now thoroughly solidified and truly monolithic. This work was performed by the Cement-Gun Construction Co. of Chicago.

Bakelite Pins for Belt Lacing

THE ANNOUNCEMENT comes from the Detroit Belt Lacer Co. that it will now furnish Detroit-Bakelite pins in place of the rawhide pins which were formerly used with its staggered-grip, wire-hook belt lacing. Tests have proven in the past that 50 per cent of belt breaks were due to failure of the rawhide pins and not to a failure of the lace. Bakelite used for this purpose offers the advantages that it is stiff; dense; water, acid and oil proof and it is uniform in texture thus providing a pin material which will outwear the lace.

KEROSENE production in November was reported to the Bureau of Mines as 234,000,000 gal., a daily average of 7,800,000 gal. and an increase of 4 per cent over the daily production of the previous month. Stocks increased 29,000,000 gal. to a high figure for the year of 337,000,000 gal. The production of gas and fuel oils during November was 1,134,000,000 gal., a daily average of 37,800,000 gal. and an increase over the daily average production of the previous month of 400,000 gal., or 1 per cent. Stocks of these oils on hand December 1 were 1,641,000,000 gal., an increase over the previous month of 30,000,000 gal.

Lubricants produced during November amounted to 95,000,000 gal. Stocks on hand December 1 were 242,000,000 gal., the lowest for the year and a decrease from the previous month of 6,000,000 gal. Domestic demand increased 8,000,000 gal. during the month to 70,000,000 gal.

IT IS NOT good practice to use rubber gaskets in the joints of economizer manifold headers for the reason that gaskets of this material soon become spongy and deteriorated. Asbestos gaskets are much more satisfactory for this purpose.

News Notes

SANFORD RILEY STOKER Co. announces the change of its name to the Riley Stoker Corporation, effective Jan. 1, 1925. This change is wholly a matter of convenience in transacting the business of the company, no change whatever in management or policy being made. The Sanford Riley Stoker Co. was founded in 1913 to make the Riley underfeed stoker. To be able to offer the trade a type of stoker best suited to individual conditions, various stokers have been added to the line by consolidating the Sanford Riley Stoker Co., Murphy Iron Works, Underfeed Stoker Co. of America and United Machine & Mfg. Co. under the firm name of the Riley Stoker Corporation.

P. ALBERT POPPENHUSEN, for 27 yr. president of the Green Engineering Co., is reentering the power plant field with an experienced organization for selling and installing power plant equipment. His wide acquaintance throughout all parts of the United States and the connections which he has formed in foreign countries, through world wide travel, together with his experience in the management of manufacture of power plant equipment, are an unusually effective preparation for the undertaking which he has in hand. The organization will be perfected in a short time, the present address being at 200 East Pearson St., Chicago.

FRANCIS C. PRATT, vice-president in charge of engineering of the General Electric Co., has been appointed to fill the vacancy caused by the resignation of G. E. Emmons, as vice-president in charge of manufacturing and chairman of the manufacturing committee. Mr. Pratt's new title will be vice-president in charge of engineering and manufacturing. H. F. T. Erben has been appointed assistant vice-president on the staff of Mr. Pratt. He will continue as vice-chairman of the manufacturing committee. Mr. Pratt's engineering assistant is E. W. Allen, appointed to the position of manager of the engineering department in April, 1924.

UNDER THE CONSOLIDATION of Vickers, Ltd., and the Combustion Engineering Corp., Ltd., both of Canada, which takes effect by the formation of a new company, known as Vickers & Combustion Engineering, Ltd., with offices in Montreal, Toronto, Winnipeg and Vancouver, the entire business of these two companies and their subsidiaries comes under one executive control.

THE INLAND UTILITIES Co. is building a new electric light and power plant at Hobart, Okla., where two 300-hp. and one 150-hp. Fairbanks-Morse oil engines are being installed. This company will run a high tension transmission line to Rocky, Sentinel, Gotebo, Mountain View and Roosevelt, Okla. The plant will be in operation some time in January.

CHAS. A. ALLEN, who for the past 30 yr. has been New York manager for the American Steam Gauge & Valve Mfg. Co., died at his home in Brooklyn, on Dec. 24, in his 69th year. Mr. Allen was born in Brooklyn and his early business career was connected with Ramsey & Co. and Silsby Fire Engine Co.

GEO. E. DULEY, formerly local manager of the department of maintenance and repairs of the U. S. Shipping Board of Boston, Mass., has been appointed chief engineer of the Tewksbury State Infirmary, Tewksbury, Mass.

THE CORDELL LIGHT & POWER Co. of Cordell, Okla., is installing two 200-hp. Fairbanks-Morse oil engines which will be in operation in the early spring months.

THE CITY OF VERNON, Texas, has recently installed a 300-hp. solid injection type two-cycle Fairbanks-Morse Diesel engine in its municipal water and light plant. This is the fourth unit of the same type which has been installed, the others being of 300, 200, and 100 hp. capacity.

THE MUNICIPAL WATER & LIGHT Co. of Altus, Okla., has recently completed the installation of a 750-hp. Fulton Diesel engine which in addition to the two former units of the same make, brings the total capacity of the plant to 1795 hp. The high tension line carrying 6600 v. transmits power to the town of Blair, a distance of ten miles.

ANNOUNCEMENT WAS made by John P. Pope, general manager of the Lexington Utilities Co. and Allied Corporations that his company had purchased the Stamping Ground Electric Light & Power Co. The old station will be operated as a subsidiary of the Lexington Utilities Co. under the management of W. D. Adams.

THE INLAND UTILITIES Co. whose general office is in Kansas City, Mo., has recently completed a plant in Elk City, Okla. One 150-hp. and one 200-hp. Fairbanks-Morse oil engines have been installed and another unit of the same make with a capacity of 300 hp. will soon be installed. This company plans to run a high tension line to Carter, Canute, Foss and Leedy, Okla., besides furnishing power to Elk City.

AT ELK CITY, Okla., the southern division of the Oklahoma Gas & Electric Co. has recently installed a 200-hp. Fairbanks-Morse oil engine, giving the plant a total capacity of 480 hp. The company also plans to replace its steam plant at Clinton, Okla., by a modern oil engine plant, two 300-hp. Worthington oil engines now being in course of erection.

THE E. K. WOOD LUMBER Co. recently installed in its Vernon, Calif., plant a 2200-sq. ft. Union Steam Pump Co. surface condenser served by a Moore Steam Turbine circulating pump handling 2400 gal. of condensing water per minute and a C. H. Wheeler wet vacuum condensate pump of the Rotrex type. The condenser just installed serves a 500-kw. General Electric steam turbine.

CONSTRUCTION has been started on a new $200,000 addition to the plant of the Globe Ice Cream Co. of Los Angeles. It is expected that the plant will be completed in 90 days and will contain a two-story ice tank room with an additional daily capacity of 200 tons of ice, thus enabling the company to produce 450 tons of ice daily. The building will also contain a concrete cooling tower.

Books and Catalogs

ELECTRICAL MACHINERY AND CONTROL DIAGRAMS, by Terrell Croft; 306 pages; 5½ by 8 in.; cloth. Price, $3.00. New York, N. Y.

This book is unique in the fact that it contains nothing but diagrams. Often the practical electrical man requires merely a circuit diagram of the apparatus or equipment with which he is working without caring particularly about any written explanation of it. This book has been compiled to satisfy such a demand. It has been the aim to

furnish a collection of 500 odd, circuit diagrams which represent more or less completely apparatus used in modern electric power practice.

Many of the diagrams which are shown are of apparatus which has been superseded by that of more recent design. Much of this apparatus, however, is still in operation and giving satisfactory service. For this reason, it is believed the diagrams of older apparatus will be of considerable value, particularly since many of the concerns which manufactured the older equipment are no longer in existence and diagrams of the apparatus are therefore no longer available. From this it should not be construed that the book is one of obsolete circuit diagrams. Instead, it is one comprising circuit diagrams of the equipment—old and new—that will be found in the average installation of today. It should be of considerable use to the practical man who is responsible for the proper operation, connection, and care of electrical machinery.

Bulletin No. 144 of the Engineering Experiment Station of the University of Illinois, entitled "Power Studies in Illinois Coal Mining," discusses first the question of the advisability of obtaining electric power for mining from utility companies. Then, since many operators have been unable to calculate the distribution among the several mining operations of the actual power expenses, the effort is made in this bulletin to assist them in securing such information.

Copies of Bulletin No. 144 may be obtained without charge from the Engineering Experiment Station, Urbana, Illinois.

"Steel Construction" is the title of a booklet just issued by the American Institute of Steel Construction, which contains the Institute's Standard Specification, and Code of Standard Practice. The introduction of the book consists of a mathematical explanation of the development of the various formulas recommended in the Specification, for the proper reduction of working stresses. Accompanying this explanation is a set of charts which reduce mathematical calculations in connection with structural steel design and data are also given on action of structural steel members under varying conditions. Copies of "Steel Construction" may be obtained from the executive offices of the Institute, 350 Madison Ave., New York, or the engineering department, 1052 Leader-News Building, Cleveland, Ohio.

The Arc Welding and Cutting Manual recently issued by the General Electric Co. has been given the designation Y-2007 and was issued "to acquaint the uninformed in a general way with some of the applications of arc welding and to provide a simple and logical method by which one may acquire a certain familiarity with the manipulation of the electric welding arc and its characteristics." The volume is divided into three parts, the first devoted to general information on arc welding, the second to a training course for operators, and the third giving a number of applications of arc welding. It is being distributed at a nominal price.

General Construction, principles of operation and exclusive features of the surface air cooler manufactured and distributed by the General Electric Company are described in Bulletin No. 45,609. A partial list of installations of this make of cooler is included.

Under the title of Homestead Valves, the Homestead Valve & Mfg. Co., of Homestead, Pa., issues its catalog No. 32, which illustrates the entire line of Homestead quarter turn valves with latest improvements in construction and other products of the company of interest to the engineering, power plant and industrial fields.

Industrial and Marine applications of Diehl Electric motors are described in bulletin No. 1652 recently issued by the Diehl Mfg. Co., Elizabeth, N. J.

Celite Products Co., of New York, has recently issued, in pamphlet form, a lecture entitled, "Heat Temperature Insulation," which is being given at approximately 50 universities during this season.

The Vater Water Softening System is the title of bulletin No. 109 recently issued by the Power Plant Specialty Co., Chicago. This bulletin is prepared especially for engineers in charge of raw water ice-making plants.

Monitor Edgewound Resistors are described in bulletin No. 67, recently issued by the Monitor Controller Co., Baltimore, Md. This new electrical resistor is intended for use with motor starters and speed controllers, and is adapted to all classes of service requiring an electrical resistor for relatively heavy currents. It is claimed to be moisture proof, acid resisting and unbreakable.

The Conveyor Corp. of America, Chicago, Ill., has recently issued a report giving information relative to an ash conveyor system installed at the terminal power plant of the Wabash Railway, Ft. Wayne, Ind. In this report are given a general description of the power plant, details of the conveyor, operation of the conveyor, tonnage handled and other features of interest about the installation.

The Botfield Refractories Co. of Philadelphia, Pa., has just issued a pocket size booklet of interest to users of firebrick. The booklet contains a number of construction suggestions such as the proper method of laying fire brick with thin but firm joints, how to coat furnace walls and other firebrick construction to protect the brick and prolong its life, the method of filling up holes and depressions with a patching mixture and how to line up single ring arches.

Roller-Smith Co. of New York has recently issued its bulletin No. 530 entitled "Standard Type Circuit Breakers." This bulletin describes two new circuit breakers, one of the double-pole interlocked trip type which is for use on motor and feeder circuits in place of switches and fuses. The other is called the shock-proof circuit breaker which is recommended for installations where there are likely to be conditions of excessive vibration.

Three new bulletins have recently been issued by The Philip Carey Co., Cincinnati, O. These are bulletin No. 104-X on heat insulation for high pressure steam; bulletin No. 101 on high temperature heat insulation and bulletin No. 103 which gives a summary of data on commercial heat insulating materials.

Fifth edition of Short Cuts to Power Transmission is now being distributed by the Flexible Steel Lacing Co., Chicago. This is a handbook prepared for belt users and it contains such useful information as: considerations in belt buying, use and care of belts, making belt joints and calculations. It also contains a chapter which deals with belt troubles and their remedy.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

The Liberators

Great changes are recorded in the memory of every reader of these pages, but what greater change have we beheld than that of our attitude toward men to whom we look for guidance in the present and to whom we give honor in the past?

A generation or two ago history concerned itself chiefly with the rulers and conquerors of the earth. Leaders of that day were quite generally men who were successful regardless of cost or purpose.

How differently most of us now measure men of yesterday and today. Mere conquerors in any field now find their power short-lived. Heroes of the past are being remeasured by a new standard, that of their service to mankind.

While the fame of ruthless conquerors dims, new pedestals are being set up for those men whose conquests founded the more far-reaching, enduring and ever-growing kingdoms of industrial, social, artistic and scientific advancement.

Once every ambitious boy could see little prospect in life except through military and political power. Today the whole realm of human endeavor offers quick recognition to every outstanding discoverer and organizer.

A man peering through a microscope, or working with test tubes, or organizing business enterprises, or straightening out the kinks in a factory or power plant, may any day win fame and honor more immediately recognized and more enduring than could be expected by any commander on the field of battle in a former age.

Substantial recognition in the form of endowment for his work, backing for his enterprise and even personal wealth are more promptly forthcoming for these winners of today than even the greatest conquerors of ancient times could hope for.

This is the age when the liberators of mankind flourish as never before and mere conquerors are passing into the discard.

Think how this change of attitude, this new consciousness of opportunity, working through a whole nation, spreading throughout the entire world, gains momentum by its own progress.

Where an ancient king sighed for more worlds to conquer, there are before us all, in every walk of life, a thousand worlds to conquer.

Where a king, with the whole world under his command, could only appoint a few thousand men to power or wealth under his brief protectorate, there are millions of men in this country alone enjoying greater personal power, luxury and security than any of his followers.

No visible limit exists to the continuation of upbuilding and expansion. Liberation of natural resources and conquest of waste, can go on indefinitely to the increasing betterment of all the people.

In the field of power this process is adding yearly to the wealth and welfare of the people.

Its service is most essential to progress in all other fields. In this field opportunities multiply with each achievement.

You who are the captains and the kings of power; the liberators of the people from drudgery; the creators of energy greater than all that the slaves and armies of ancient kings could bring to bear, also have other armies on your side.

Always at hand, yours to command, ever working in your behalf, are the loyal engineering and manufacturing organizations who advertise here.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR CHAMBERS.
Hercules Float Wks., Springfield, Mass.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
American Well Works, The, Aurora, Ill.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.

ALARMS, HIGH AND LOW WATER
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Girtanner Engineering Corp., New York, N. Y.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Jointless Fire Brick Co., Chicago.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Girtanner Engineering Corp., New York, N. Y.

ASH CONVEYING SYSTEMS.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engineering Corp., New York, N. Y.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyors Corp., Chicago, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
United Conveyors Corp., Chicago, Ill.

ASH TANKS.
United Conveyors Corp., Chicago,

BEARING METAL.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co., (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany, N. Y.

BELT LACING.
Bristol Co., The, Waterbury, Conn.
Flexible Steel Lacing Co., Chicago.

BELTING.
New York Belting & P'k'g. Co., New York.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Diamond Power Specialty Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, TURBINE.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
King Refractories Co., Inc., Buffalo, N. Y.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
Obermayer Co., The S., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corporation, Philadelphia, Pa.
Bethlehem Shipbuilding Corp., ,Bethlehem, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Page Water-Tube Boiler Co., Chicago, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw, Mich.

BOOKS AND SCHOOLS.
Hays Institute, The, Chicago, Ill.
McGraw-Hill Book Co., Inc., New York, N. Y.
Sweet's Catalogue Service, Inc., New York, N. Y.

BREECHINGS.
Littleford Bros., Cincinnati, O.

BRICKS, FURNACE LINING.
Norton Co., Worcester, Mass.

BRUSHES, DYNAMO AND MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, CLAMSHELL.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Girtanner Engineering Corp., New York, N. Y.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry. Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York.

CLEANERS, BOILER TUBE.
Chesterton Co., A. W., Boston.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.

CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.

COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Link-Belt Co., Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.

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